WASY Software

WBalMo® 2.2

Interactive Simulation System for Planning and Management in River Basins

User's Manual

WASY GmbH
Institute for Water Resources
Planning and Systems Research

Preface

How to use the manual

This manual, which is identical to the help menu in general, describes the Simulation System WBalMo.

Chapter 2 describes the software application basis for the Simulation System GRM.

Chapter 3 gives a short overview of the GIS program ArcView, which serves as a framework for the Simulating System WBalMo. Further information about ArcView can be obtained from relevant ArcView publications.

Chapter 4 explains the theory of the management model which is a long-term stochastic management model.

The description of the models' original structure and its implementation follows in chapter 5. All data and menu structures are explained in detail.

Chapter 7 presents an example.

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WASY GmbH
Institute for Water Resources
Planning and Systems Research

Waltersdorfer Straße 105
D-12526 Berlin
Germany

Phone: +49(0)30-67 99 98-0
Fax: +49(0)30-67 99 98-99
E-Mail: mail@wasy.de
Internet: http://www.wasy.de

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Introduction

1

Based on the knowledge of a river basins structure, its specific natural runoff and water resource processes, the quantitative behaviour of a river basins water resource system can be examined with the WBalMo simulation system under various conditions.

The management model, which forms the basis of the WBalMo simulation system, operates according to the Monte-Carlo-Technique. River basins water utilisation processes can be reproduced, covering any space of time in time-steps of one month. The registration of relevant system states allows a statistical analysis of registered events after completion of the simulation. As a result approximate probability distributions for values, such as reservoir storage level, water supply deficiency for individual water users or for discharge at selected river profiles, are available. Due to this, the quality of a selected management strategy can be assessed for the investigated river basin. An improved strategy can be obtained by gradually changing the variables.

The stochastic input quantities and the deterministic reproduction of water utilisation processes are separated dealt with in WBalMo. The basis for WBalMo calculations are chronological series of input sizes for the chosen space of time, on the basis of a month. Usually these input sizes are generated by a stochastic simulation model under compliance with time-dependent conditions for drainage formation.

The simulation of the water utilisation processes is based on the following assumptions:

- WBalMo uses schematic representation of hydrological processes in a river basin by Running Waters and Balance Profiles.
- By subdividing the whole basin area, Simulation Sub Areas are created and the above named series of discharge is assigned. This discharge is then divided among Balance Profiles as natural yield.
- Consideration of water Users takes place according to their location and size, by

withdrawing and / or feeding back the demanded water from / to Balance Profiles, respectively.

- WBalMo includes Reservoirs (barrage systems, lakes) by settings of their location, Capacity and Release-elements, which describe their demand-orientated operation.

The WBalMo simulation system is the ArcView desktop implementation of the GRM management model. Since the end of the 1970's this simulation model has been developed in Berlin by the **Institute for Water Resources** as a special, user-friendly long-term management model. It was made available as a mainframe application in 1983.

In 1992 a desktop version of the GRM model was developed, whose exclusive rights are owned by WASY Ltd. As framework for a management model for the region Niederlausitz PC-GRMDYN was developed from PC-GRM subsequently. This region is highly influenced by open-cast mining. PC-GRMDYN is characterised by modelling fundamental system elements on the basis of nonstationary (dynamic) data.

With the henceforth existing WBalMo simulation system, both stationary (PC-GRM) and dynamic processes (PC-GRMDYN) can be modelled within river basins. Further fundamental innovations in WBalMo are:

- System sketch visualisation of the river basin within the simulation system,
- Filing of model data in a data base and
- An interface for external models, which enables specific investigations (e. g. water quality, simulation of daily values) on the basis of the WBalMo quantity model.

A flexible model for river basin management is available with the WBalMo simulation system. Essential examples are:

- Management and general regulation for river basins in accordance with EU guidelines
- Operation plans for water resource plants and for supplying water users
- Provision of reports for investment projects
- Proceedings concerning water rights.

In particular WBalMo provides a useful tool for the anwering of questions concerning the water management of river basins, in which serious water balance interventions are expected in the future (e. g. intensive mining with connected groundwater lowering, commissioning of new reservoirs).

1.1. List of Abbreviations and Symbols

AB-Element	Reservoir Release-element
AE	Actual User withdrawel according to its balance
AEND-Element	Release-End-element, AB-element for return of unused water in a Reservoir or in a Reservoir Association
ANZP	Number of Periods
ANZR	Number of Realizations
Bp	Balance Profile
BETA	Coefficient for a calculation of Target Storage Level depending on SIA
CR	User type: User with constant return flow (for example sewerage treatment plant)
DYN-Element	Dynamic-element, FORTRAN-text to interrupt standard algorithm and integrate individual modelspecific routines
E	User demand, plan value
FSK	Relative Initial Reservoir Storage Level at the start of the calculation
G	Target Storage Level [hm³]
GR	Limit for Reservoir slices in the case of water management with Associated Reservoir Operation [hm³]; GR £ NG
IGR	Number of slices up to GR in which the Reservoir Capacity is divided in the case of Associated Reservoir Operation
ING	Number of slices from GR up to NG in which the Reservoir Capacity is divided in the case of Associated Reservoir Operation
LP	Length of Period in years

NG	Active Reservoir Capacity [hm³]; Size of active storage
Qmin	User type: minimum discharges
R	User type: User with demand and return flow, plan values
R	User return flow, plan value
SI	Reservoir Storage Level during or after calculation in the time-step of a month [hm³]
SIA	Reservoir Storage Level (filling) at the beginning of the month [hm³]
SK	Reservoir Capacity [hm³]; maximum active storage size within a year
STG	Simulation Sub Area
Z	Rank of Release-elements, DYN-elements, User or AEND-elements

1.2. New Features in Version 2.2

General Program Properties

- Language Support
  - o German
  - o English
- Changes in exporting variants
- Directory-browser, open variant
- Converter Version 1 -> Version 2
- Additions to WBalMo-options
- 32 Bit Windows-application of the simulation system
- Revision of the documentation
- HTML-help

Data

- Editing of period borders
- Setting and examination of equal ranks in periods
- User-defined Units, Units in SSA, for Users and registrations
- Data class CC-field
- Ranking list
  - o Output as HTML-file

  - Variants name on printout
- Extension of the report with new data, storage as HTML-file
- Comparing variants
- Test of data of SSA-series

Handling

- Representation of the waters name for Balance Profiles
- Click on elements in system sketch simplified
- Sorting of registrations for the result file
- Automatic name assignment for unnamed elements of Running Waters, DYN-elements and registrations

Extended Modelling

- Uniform internal Units (also Q in hm^3/Mon)
- Adjustment of the GRM-Kernel to FORTRAN 90, for better use of newer features
- Definition and Integration of FORTRAN-modules as well as variant-specific parameter files
- Interface to external functions from DLL
- Simulation System
  - Run-time monitoring
  - Plausibility checks
  - Output / Messages from DYN-elements
  - Determination of the CPU use
- Additional functions for program control
- CONSOLE instructions BREAK and WRITE are to be initialised
- Integration of the debugger (MS-Visual-Studio)
- Insertion of name of the DYN-element in exported source code
- Reference to write-protected files in the standard working directory.

Simulation System WBalMo

2

2.1. System Requirements

Minimum Hardware Requirements

- CPU Pentium II, 266 MHz
- 64 MB RAM
- ca. 60 MB hard disk capacity for ArcView
- ca. 260 MB hard disk capacity for DIGITAL Visual Fortran
- ca. 20 MB hard disk capacity for WBalMo
- Mouse or compatible pointing device
- SVGA-graphics card and monitor with a resolution of 1024 x 768 pixel with 256 colours
- CD-drive for installation of WBalMo and FORTRAN-compiler
- Parallel interface for the dongle on the license server

Minimum Software Requirements

- Windows NT 4.0 with Service Pack 3, Windows 2000 or Windows XP
- installed and set up TCP/IP-Protocol
- ArcView 3.2 with installed Dialog Designer
- Compaq Visual Fortran 6.6
  - The installation of this package is mandatory for duly licensing of the used compiler files for WBalMo. **During** the WBalMo set up the Fortran-CD is requested to copy the data necessary for WBalMo.

2.2. Installation and Configuration

- WBalMo is supplied on a CD. The installation takes place via execution from setup.exe on this CD. The following modules can be installed:

a) WBalMo-Program files

Installation of files necessary for WBalMo, setting up of the directory and the program group „WBalMo“.

- The program group „WBalMo“ is available to all (common) users.
- The environment variable WBalMo2 is entered as user-independent system variable.

b) Fortran-Files required by WBalMo

- During set up the CD of the Compiler Compaq Visual Fortran 6.6 is required. The files necessary for WBalMo are copied.

c) License-Manager

Installation of components necessary for the dongle on the license server.

- After the installation of the driver HARDLOCK is started.
- Subsequently WASYNetlm is started.

The setting up of the license server can take place together with the installation of WBalMo / Compiler (e. g. by a license and utilisation of WBalMo on one computer). When installing WBalMo on several computers, the setting up of the license server is necessary only once.

d) Compaq Visual Fortran 6.6

- The files copied under b) are licensed only with installed Visual Fortran. Otherwise some components cannot be used.
- Especially for complex Models / Program routines Visual Fortran can be used as a Debugger.
- No variant calculations can be executed if this point is deactivated, e. g. DEMO-license without Compiler.

e) Files and Directories

```
...
%WBalMo2%
    Wbalmo_v2.apr
    bin
        WBalMo.exe
        arcgrm.msg.exe
        dll4av.dll
        icomp.exe
        netlm.dll
        netlmsvc.exe
        netlmadmin.exe
        netlmhostid.exe
    doc
    dvf
        DECFOR90.EXE,
        DF.EXE,    FL32.EXE,
        FL32_HLP.TXT,
        LINK.EXE,
        MSPDB60.DLL,
        NMAKE.EXE
        ADVAPI32.LIB,
        COMDLG32.LIB,
        DFCONSOL.LIB,
        DFORDLL.LIB,
        DFPORT.LIB,
        DFWIN.LIB,
```

```
    GDI32.LIB,
    KERNEL32.LIB,
    LZ32.LIB,   MPR.LIB,
    MSVCRT.LIB,
    ODBC32.LIB,
    ODBCCP32.LIB,
    OLE32.LIB,
    OLEAUT32.LIB,
    SHELL32.LIB,
    USER32.LIB,
    UUID.LIB,
    VERSION.LIB,
    WINMM.LIB,
    WINSPOOL.LIB,
    WSOCK32.LIB
    ADVAPI32.MOD,
    COMDLG32.MOD,
    DFLIB.MOD,
    DFWBASE.MOD,
    DFWIN.MOD,
    DFWINTY.MOD,
    GDI32.MOD,
    KERNEL32.MOD,
    LZ32.MOD,   MPR.MOD,
    SHELL32.MOD,
    USER32.MOD,
    VERSION.MOD,
    WINMM.MOD,
    WINSPOOL.MOD,
    WSOCK32.MOD
  etc
    WBalMo.avx
    WBalMo.gif
    WBalMo.ini
    color.odb
    console.pif
    debug.dsp
    debug.dsw
    debug.ncb
    debug.opt
    grmlb.lib
    legend0.odb
    legend.odb
    makefile
    setup.bmp
    wasy.gif
  help
    wabalmo200de.chm
  tmp
  var
```

2.3. Licensing with NETLM

Licensing of WBalMo takes place via a dongle. It is a matter of licensing with allocation and management of one or several network licenses. Moving a dongle is therefore unnecessary for utilisation of WBalMo on several computers.

Setting up a License Server

The following steps are to be accomplished with a network installation and an administration of several licenses:

1. Establishing a license server

- Putting the dongle on the parallel interface and installation of the driver

2. During installation of WBalMo automatically

- HARDLOCK and NETLM are installed as service.

3. After the first start the license properties are to be filled in:

- NETLM has to be active.
- File card „Connection“: Input of license server (TCP/IP-address or „localhost“). Connect to server. Field „Host ID“ is occupied by NETLM.
- File card „License“: Enter the data of the delivery note into the fields. Complete input of all data by „Install“.

Licensing Run-Time

Project

Menu Help

License

Each time WBalMo is started the validity of the license is inspected. A software system DEMO-mode is activated when an error occurs (license server unavailable, dongle missing, NETLM not started). This DEMO-mode can only be exited by a regular license assignment through NETLM:

- inspection of license server and dongle
- starting NETLM when required
- call up the function „License Information“, file card „Connection“: „Connect“ to server
- File card „License“: if necessary enter the „License Properties“ (see above)
- NETLM is regulated via switches:
  - o -install: installs NETLM as Windows NT service
  - o -remove: deletes NETLM service
  - o -debug: starts NETLM as console

2.4. DEMO-Version

The number of model elements in the DEMO-version is limited:

- 15 Balance Profiles
- 3 SSA (Simulation Sub Areas)
- 2 Reservoirs
- 3 Releases
- 10 User
- 2 DYN-elements
- 40 C-field-elements
- 10 registrations

The limitation is effective for:

- the creation of new and for editing existing model elements,
- the drawing up of ranking lists and reports,
- the execution of variant calculations.

2.5. Starting the Program

The file `WBalMo.apr` is opened by ArcView if WBalMo is opened with the icon „WBalMo“ in the program group „WBalMo“ from the task bar. Variants contained in `WBalMo.apr` are available then.

WBalMo-variants saved in other `*.apr` files can be opened by double clicking their Icon in the File manager / Explorer by ArcView.

If no valid license is available at the start of the program, the function „License Information“ is activated. See chapter 2.3 Licensing with NETLM.

Standard settings are generated the first time WBalMo is started. These options can be modified when required.

2.6. Options

The options are valid for all WBalMo-projects and variants. They are saved in the file `WBalMo.ini`.

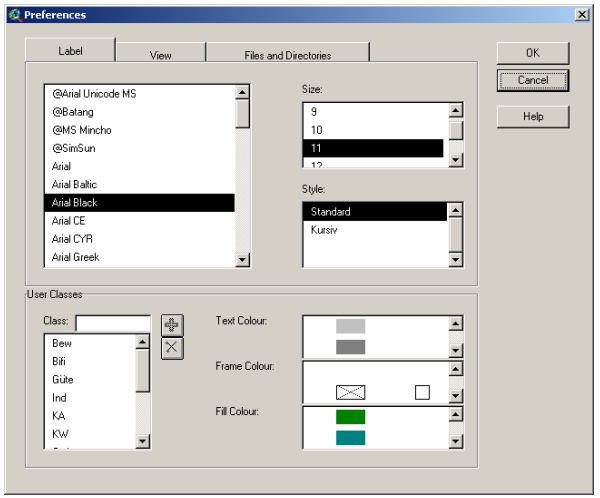
Project

Menu WBalMo

Options

Button

Labelling



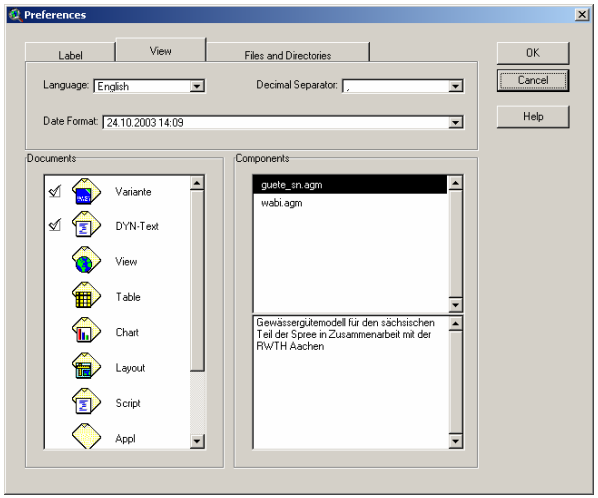
Options for automatic labelling of the system sketch:

- Choice of font
- Establishing font style (bold, italic, ...) and initial font size (6 .. 20 points)

Labelling of Users:

- Combination of text- and frame-colours for labelling of Users depending on their class. The affiliation of a User to a class is specified with its definition by an abbreviation (chapter 4.3 Model Element).

View



Language:

- Choice of language for the graphical interface elements

Decimal separator:

- Preference for copying tables into the clipboard to insert into a spread-sheet analysis (e. g. result file, ranking list)

Date format:

- Selection of date-format for presentation in the report, properties of the variant, ...

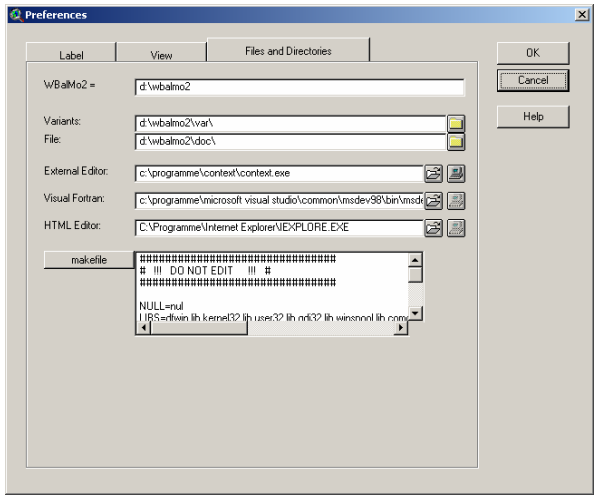
Documents:

- By double clicking further ArcView-documents can be displayed and used in the project. In the same way they can be switched to invisible.

Components:

- Information about installed WBalMo-modules

Files and Directories



WBalMo2:

- Information about the value of the environment variable WBALMOHOME

Variants:

- Setting the standard-directory in which data of variants are stored as sub-directories
- With the creation of new variants the set directory is offered first.

Filing:

- Setting of the standard-directory in which output files are stored (simulation results *.sim, ranking lists, reports, ...).
- For storing created files the set standard-directory is offered first. If desired the directory can be changed.

External Editor:

- By establishing its path and file name an Editor for DYN-elements and DYN-texts is specified. The Standard Editor is the Windows-Editor Notepad.

Visual FORTRAN:

- Visual FORTRAN is used for debugging DYN-elements during simulation.
- Establishing path of file `dfdev.exe`

HTML-Editor:

- Report, variant comparison and ranking list can be created as HTML-files and viewed in WBalMo with a suitable program.

makefile:

- Display of used compiler- and linker options

ArcView Crash Course

3

3.1. ArcView

The ESRI Inc. GIS ArcView system forms the basis of the WBalMo interface including representation of the structure pattern. Some basic ArcView features, relevant to the WBalMo-application, are explained below. Details concerning ArcView can be found in its application documentation. In ArcView-**projects** the following object classes are available: **Views**, **Tables**, **Layouts**, **Charts**, **Scripts** and **Dialogues**. A project combines documents derived from the named classes, which are administered together in a file (*.apr). **Projects do not contain any data, they refer only to data sources such as tables, vector and raster maps.**

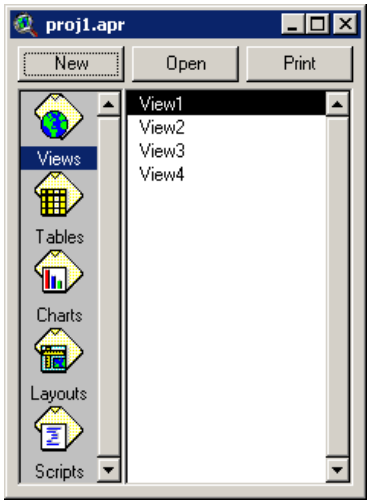
Overview of the ArcView Documents:

Views	A View is an interactive map which displays geographical data, as well as it enables data to be examined and analysed.
Tables	A Table enables data to be examined, edited, combined, scanned / sorted from tabulated data sources.
Charts	A Chart is a graphical representation of data in a table.

Layouts	In order to prepare maps within ArcView for printing Layouts are used. Layouts enable the representation of different documents such as charts, tables, imported graphics and basic graphical forms in one map.
Scripts	In general a Script contains AVENUE-code, an interpreter language. Scripts are comparable to macros and procedures of other programming languages. Avenue-scripts serve task automation, adding of new functions and the development of entire applications under ArcView (ArcView-applications).

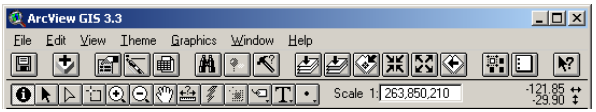
3.2. Graphical Interface

When opening a project, a project window containing project file names appears inside the program window. These documents are contained in the project: Views, Tables, Charts, Layouts, Scripts and Dialogues.



Each document is displayed in a separate window. Several windows can be opened at the same time in ArcView. However, there is only one active window at any time.

The ArcView-project window contains a menu, a button tool bar and a tool bar at the top of the screen, which perform ArcView commands. The content of these bars depends on the type of active document / window. The status bar can be found at the base of the project window.



The **menu** offers various commands in the form of pull down menus.

Via buttons in the **button tool bar** frequently used commands from the menu are available.

The **tool bar** makes it possible to work with various tools in the active document. Selection is

carried out by clicking on the desired tool. Tools are either arranged individually or in vertical tool menus. The shape of the cursor depends on the tool. A tool stays active until another tool is selected

The **status bar** informs you about ArcView-activities (verbal, status) as well as outcomes of several interactions, e. g. measured distances or areas.

ArcView was adjusted for the input, representation and analysis of the GRM management model data by a number of programmed scripts in AVENUE and by modification of the user interface. Furthermore WBalMo contains an interface to the GRM-calculation module. This part of the simulating system acts as ArcView-extension. ArcView-projects basing on this extension and fulfilling the installation requirements can manage (any number of) variants of one GRM or of different GRM.

3.3. ArcView-Application WBalMo

WBalMo is an ArcView-application.

WBalMo uses the following document classes named in the overview:

Variants	**Variants** are views containing all model elements (Running Waters, Balance Profiles, Simulation Sub Areas, Reservoirs, Users) of a WBalMo-variant in the form of a **system sketch**. All variant-linked operations (data input and editing of non-spatial applied data, start and analysis of simulation calculation) are carried out via this document.
DYN-texts	Program texts for DYN-elements, modules or external files such as scripts can be edited in DYN-texts. Filing of texts is carried out independently of variants maintained in the project: Changes in these texts have to be followed by editing the corresponding DYN-elements of one or more variants..

Basis of the Management Model

4

4.1. Time Basis

The simulation system WBalMo serves the reproduction of water yield and water use processes either in a **balance period** or in a **balance year**.

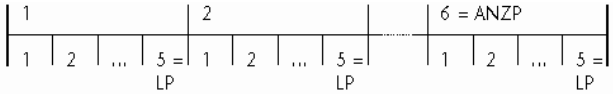
A **balance period** is usually a future space of time divided in equally long **period**s, consisting of several years. The conditions for natural water yield and water demand may change from **period** to **period**. Examples are variable flow regimes in mining areas caused by changing catchment area borders. Furthermore the expected development of water demand from water Users or the start up of new Reservoirs with nonstationary filling phase can be arranged precisely in time.

A **balance year** is used when the conditions of a particular calendar year are to be examined. The balance year is a special form of the balance period.

The balance period or balance year is sufficiently often simulated with a different, stochasticly generated water yield. In this way precise results concerning the effectiveness of the water management system can be obtained. A sequential (monthly) reproduction of one balance period is called a **realisation**.

Examples

- **Balance period 2003-2032**, divided into 6 periods, each of 5 years in length
  - WBalMo performs a defined number ANZR of realisations of the balance period. Each balance period consists of ANZP=6 periods, made of LP=5 years with 12 months. 100 realisations usually are sufficient.
  - The time structure of a realisation is shown below:



- **Balance year 2010**
  - The river basin is simulated (monthly) LP-times under the conditions of the year 2010. Usually LP= 1000 realisations are sufficient.

The **time-step for balancing** is in principle a **month**. In WBalMo it is assumed that all operations concerning the river basins discharge processes, by water utilisation or by Reservoir releases, become effective completely across the whole river basin for each month observed. Therefore run-times and strong nonstationary drainage phases cannot be taken into consideration generally. Nevertheless its modelling is desired in very large river basins or during flood phases. In this cases the integration of a corresponding module (e. g. hydraulic model, rainfall-runoff-model) via so-called DYN-elements is possible.

In the model a standard length for months is used for calculation

$$\frac{365 \text{ days}}{12} = 2.628*10^6 \text{ s}$$

4.2. Balance

WBalMo solves water management problems in river basins on the basis of a simulation model. This is carried out by a monthly location specific comparison (= balancing) of natural water yield and the consumer demands over a sufficient number of simulations of the balance **period** or balance year. Requirements on water supply from Reservoirs are considered. Balancing includes registration of relevant events. This enables the calculation of water supply reliabilities via a statistical analysis (mean, extreme values) after the simulations end.

The creation of a WBalMo for a river basin starts with the graphical description of its water management system in the form of a system sketch. The following are necessary:

- the relevant river net with Balance Profiles (BP) for location specific classification of water management objects,
- borders of the Simulations Sub Areas (SSA) for the allocation of the natural water yield,
- water Users with corresponding points of demand and return flow at the defined BP,
- Reservoirs.

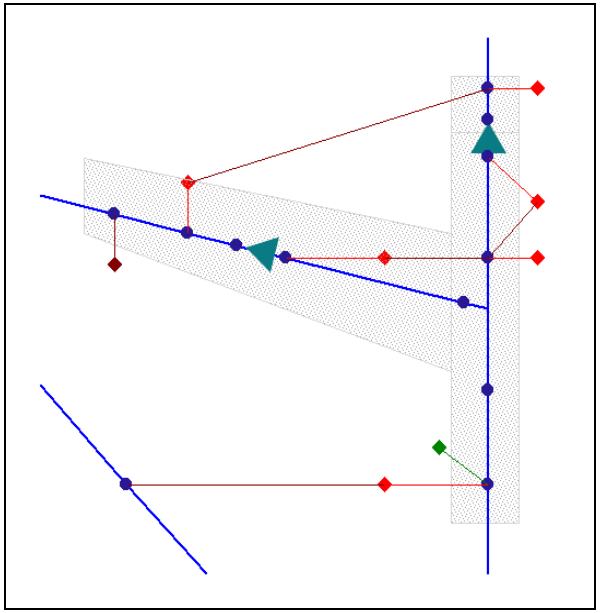
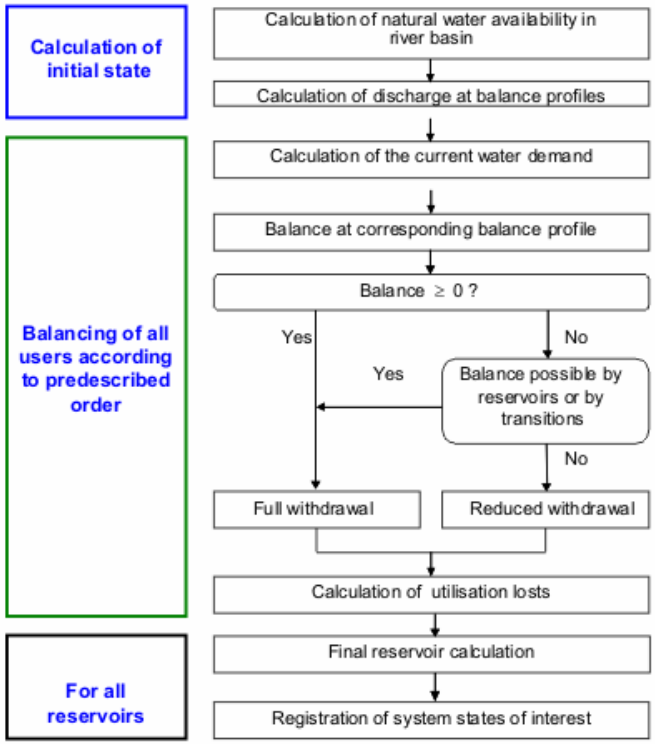


Diagram of a river basin

An application of WBalMo demands, that time series of mean monthly natural yields exist for all Simulation Sub Areas, in which the respective river basin has been subdivided. This can either be an observed time series when revised from management affects or unaffected time series. They also may be stochasticly generated on the basis of revised discharges. The latter case, which is an application of the Monte-Carlo-Technique for water management problems, should be preferred.

Utilisation processes are modelled by Users, Reservoir Releases (Release-elements and AEND-elements) and so-called Dynamic Elements (DYN-elements) in WBalMo. These model elements receive a rank (chapter 4.4 Ranking List). Concerning a User this rank represents its importance in the system of all Users in the river basin. Release-elements and DYN-element ranks serve their classification in the consumer hierarchy.

Balancing takes place gradually within a month according to the sketched drainage diagram.


Calculation of initial state
Balancing of all users according to predescribed order
For all reservoirs
Calculation of natural water availability in river basin
Calculation of discharge at balance profiles
Calculation of the current water demand
Balance at corresponding balance profile
Balance ≥ 0 ?
Yes
No
Yes
Balance possible by reservoirs or by transitions
No
Full withdrawal
Reduced withdrawal
Calculation of utilisation losts
Final reservoir calculation
Registration of system states of interest

Accounting the Natural Water Availability

The relevant monthly discharge is taken from the discharge-files for each SSA. The SSA discharges are subdivided into shares for areas between adjacent Balance Profiles in this SSA, and finally added in the direction of flow. The outcome is a natural discharge state in the river basin.

Water Utilisation Balance

At the beginning of a monthly balance all Users, Release-, AEND- and DYN-elements are filed into an active list in ascending order of their ranks, respectively. The active list is then gradually processed, starting with the lowest rank. The Users are supported by water releases from the

Reservoirs, if disturbances in the water supply are imminent.

The described processing of the ranking list gradually transfers the natural discharge of a river basin into a managed final state for each month examined. Only this final state is of interest to water management. The WBalMo principle of instant discharge change on all concerned Balance Profiles in the direction of flow allows the balancing of withdrawal, return flow or Reservoir releases as sketched.

Registration of relevant variables of state such as discharge at chosen Balance Profiles, actual water withdrawal by particular Users or current Storage Levels of individual Reservoirs only takes place at the end of the monthly balance.

4.3. Model Elements

4.3.1. Running Waters and Balance Profile

By taking into account Running Waters in the investigated area the model structure is defined.

Balance Profiles serve the division of water yield for Simulation Sub Areas and the determination of locations of water management utilisations in the river basin. Reservoirs are always placed between two Balance Profiles. In addition registrations of system states such as discharges are possible at these profiles.

4.3.2. Simulation Sub Area

The river basin is to be partitioned into so called **Simulation Sub Areas (SSA)** for the registration of the **water yield**. Corresponding series of observed, from management affects revised, or simulated discharges are to be provided for each SSA. As time unit, one month is used. For each SSA, discharges are to be chronologically separated and stored into files on the basis of the calendar year.

The discharge series required for WBalMo consist of observed mean monthly discharges at the considered gauges. These are to be revised from the following management and utilisation affects:

- Water losses due to water utilisation in communes, industrial and agricultural settings,
- Reallocation of natural yield by Reservoir management with regard to time,
- Spatial reallocation of natural yield by transfers.

The corresponding series can be directly transferred to WBalMo, where the maximum simulation length is limited by the observed series length. By applying stochasticly generated series of sufficient length the implied lack of low accuracy of results can be avoided. However, the construction of a **stochastic simulation model** is required. For the necessary work, **SIKO** software

is available for a mathematical statistical analysis of the revised discharge series and for calculation of simulation conditions, as well as **SIMO** software, which is used to generate series of any length. [SIKO/SIMO - Programme zur stochastischen Simulation, *WASYsoftware*, 2000]

If it is impossible to revise the discharge series, e. g. as a result of mining influences, the use of rainfall-runoff-models and stochastic simulation of meteorological data, such as precipitation and potential evaporation, are necessary. The rainfall-runoff-model EGMOD, which also works on the basis of one month periods has proved worthwhile for lowland areas and mining regions.

Since the division of a river basin into SSA is coarser than by given Balance Profiles, a division of SSA discharges in general has to be carried out. This is done according to areas between profiles.

- The shares determine the discharge of the area between the respective Balance Profile and upstream profiles. With river mouths there are thus several upper profiles.
- Negative portions are permitted. They are required for the formation of SSA discharge according to the differences of gauge values.
- Profiles without separate availability have no share of a SSA water yield (relative portion is equal to 0).

By successive addition of SSA discharges in the direction of flow the initial discharge rates at all Balance Profiles are produced at the beginning of each WBalMo monthly simulation.

4.3.3. User

Acquiring the **water utilisation demands** of a river basin takes place by defining the Users according to their location, monthly **withdrawal demands E** and the accompanying **return flows R** as well as their **ranks Z**, which describe the Users importance in the whole system. If the values of E, R, and Z, respectively, are equal for all calendar months, the input of a single value for the **whole year** is sufficient. Otherwise the input of data with an annual cycle is possible. The balancing of Users is carried out in ascending order of ranks in WBalMo, which means the lower the ranking the higher the priority for water supply. If deficits arise, reduced and demanded withdrawal are in the same relationship as reduced and planned return flow.

There are three types of Users:

- **R**+/-: Users with withdrawal and return flow at one profile or at two different profiles with/without availability of return flow for Users of lower priority,
- **CR**+/-: Users with return flow at a profile with/without availability of return flow for Users of lower priority,

- **Qmin**: minimum discharge at a profile.

Several Users may be attached to a profile. Their balance takes place according to their ranks. The ranking of these Users must then coincide with their location in the flow direction.

User demands are defined in the form of several Users; if

- the overall demand of the Users can be partitioned into different ranks (different significance of separate demands) or
- the proportionality between actual withdrawal and return flow does not correspond to reality in the case of deficit.

With the summary of Users of a balance area in a profile, attention must be paid to the fact that values of withdrawal and return flow quantities are not added.

Values of withdrawal and return flow quantities are positive, thus $\mathbf{0} \leq \mathbf{R} \leq \mathbf{E}$.

- As an exception the combination $E = 0$ and $R > 0$ is permitted, if User type CR is balanced. Such a combination could particularly arise by the input of annual cycle, e. g. with fish pond management (months with either only withdrawal or return flow).

4.3.4. Reservoir

In WBalMo only the Active Capacity of a **Reservoir I_{BR}** or R3 is considered. The entry of annual cycles for the value of this Active Capacity is possible (**NG**). The maximum Active Capacity within a year is called **Storage Capacity SK**.

In agreement with Reservoir management experience, three premises for Reservoirs in a river basin are applied in WBalMo:

- A Reservoir or a group of Reservoirs (**Association**) supplies, with priority or exclusively, a User or a group of Users with water.
- A Reservoir or Reservoir Association provides as much water in the regulation as is necessary for full water satisfaction of affiliated Users or User groups (**demand-orientated Reservoir management**). Exceptions occur during dry periods in the form of deficits (low Storage Level) and in wet periods in the form of surpluses (Reservoir overflow).
- For a Reservoir also a **mandatory release** can be set, which has to be met if possible.

Implementation of this concept takes place in WBalMo by definition of a Reservoir regarding data of its size, initial filling and Association if given:

- Definition of so-called Release-elements to calculate water quantities, which are available in the Reservoir for Users.
- Implicit fixing of User groups to be supported directly by releases only by ranks of AB- and AEND-elements.

Since the balance in WBalMo takes place gradually according to the ranking list, the availability of Reservoir volume is changed by intersection with a **Release-element**. The availability is increased, if the following User in the ranking list is to be supplied as a matter of priority from this Reservoir, otherwise it is lowered. Dependent on the Reservoir Storage Level an increase or a decrease of availability takes place by a Reservoir release, which is immediately realised, or by reduction of releases, which have already been operated, respectively. This is carried out without disadvantaging against Users of lower ranks which have already been balanced.

On the other hand an active **AEND-element** terminates the operation of the Reservoir in the respective month. Users with higher ranks than the AEND-element are excluded from supplies of this Reservoir.

A Release-element makes available a determined maximum quantity of water for the group of Users to be supported. This is carried out inside the program by reducing the volume of the Reservoir to the minimum Storage Level (purely by calculation), which is to be set by a limit value G and / or the coefficient BETA. While working off the AEND-elements, after the balance of the Users affected, it is determined what quantity of the amount of water potentially available actually was required by the Users. The amount of water not required is "calculated back" into the Reservoir. As a result the Reservoirs actual volume and the Reservoir releases are received.

Several Release-elements have to be defined if a Reservoir has to supply various User groups with different reliabilities. The ranks of the respective Release-elements are to be arranged before the ranks of the User groups.

The implementation of the above concept for Reservoir management is performed gradually too. Only the final state after working off the entire ranking list is practically relevant.

AEND-Element

A water quantity for a particular group of Users is often released to the lower reaches of the relevant Reservoir by a Release-element, which commonly exceeds the actual necessary quantity. Thus it was avoided to calculate a necessary Reservoir release for each individual User in the model. In order to be able to reproduce the demand-orientated management, an end calculation has to be performed each month for every Reservoir. This end calculation "calculates back" the water, which was not claimed by the Users, into the Reservoir. The Release-End-elements (AEND-elements) according to their ranks enable two kinds of end calculations and by this of Reservoir regulation.

Individual Reservoir Regulation

If an individual regulation AEND-element is activated while gradually working off the ranking list, the quantity of water not required in the lower reaches of the Reservoir is determined. Under consideration of the Reservoirs Storage Level the current volume of the Reservoir is increased by this quantity and the discharge rate is reduced in the lower reaches accordingly. The order of this end calculation and therefore the order of Reservoir utilisation can be established by AEND-element ranks: low AEND-element ranks indicate priority for replenishment of the Reservoir, which in the end corresponds to low utilisation. In comparison a high rank leads to higher demands on the considered Reservoir. In this way the rank of an AEND-element describes the Reservoirs degree of protection.

Associated Reservoir Regulation

For even utilisation of a Reservoir Association in a river basin the use of the implemented associated regulation in WBalMo is possible. With this the current free storage Capacity of each Reservoir in the Association is divided by the limit value **GR** into two segments. This current free storage Capacity is the volume between the current Reservoir Storage Level **SI** adjusted by the last Release-element and the active Reservoir Capacity level **NG**. The "return calculation" is carried out in two stages, first up to the **GR** storage level, then up to **NG**. The aspired even, proportional utilisation of all associated Reservoirs is attained by subdivision of both capacities of all Reservoirs into similar sized „slices“ **IGR** and **ING**. Surplus Reservoir releases are shared amongst Reservoirs in an Association by the algorithm in such a way that the first slice of all Reservoirs is filled first of all, then the 2nd ,3rd etc. Dependent on the Reservoir location and the utilisation conditions within the individual river courses the possible maximum proportionality of the Reservoir utilisation is achieved. The standard value 10 appears sufficient as a slice number. **No** other elements are allowed to be performed by their ranks between the ranks of all AEND-elements of an Association.

Mandatory Release

If a mandatory release is to be forced, e. g. in connection with User type Qmin, this AEND-element is needed. After the emptying of the concerned Reservoir at the beginning of balancing in a month and after balancing of all Users upstream of this Reservoir, this Qmin-user is to be balanced and the AEND-element activated directly on it. The aspired quantity of the mandatory release can be adjusted by E-values of the User or via a DYN-element.

The application of mandatory release brings about a strict separation of balance of all Users upstream of the Reservoir from all Users downstream. In this case a priority of water supply for Users downstream is not possible.

4.3.5. Release-Element

Availability of the current Reservoir volume for particular Users and the quantities of Reservoir releases are adjusted via the ranks of the Release-elements in WBalMo. For a Release-element this adjustment is performed by gradually working off the ranking list for all Users, Release-, AEND- and DYN-elements. This remains valid for all following Users of higher rank in the ranking list, until availability is changed by a further Release-element of the same Reservoir or by the Reservoirs **AEND-element**, which completes the calculation in the current month. Several AB-elements can be defined for each Reservoir.

At the beginning of a month standard availability for all Reservoirs is regarded as **Output** = **Inflow**, i. e. the current Reservoir Storage Level SI = SIA remains unchanged.

Availability is set by both entry sizes **G** and **BETA**, and calculates a limit **GW.**

GW = MAX (**G, BETA • SIA**)

The following operations are effected:

- Raising of availability if **SI** > **GW** (GW = **minimum Storage Level**) with
  - o Lowering of Reservoir Storage Level till **SI** = **GW**
  - o Raising Reservoir release to **SI** – **GW**, increasing the discharge rate on all downstream profiles by this release
- Reduction of availability if **SI** < **GW** (GW = **maximum Storage Level**) with
  - o Calculation of discharge rate portion **H** in the lower reaches, which is not yet balanced (so called „free rate“)
  - o Raising Reservoir Storage Level till **SI** = MIN (**GW, NG, SIA, SI,** + **H**) for reserve formation
  - o Corresponding degradation of Reservoir releases and discharge rate in the lower reaches.

Thus it appears that

- the value of GW can be effective as minimum or maximum level respectively, depending on the value of SI (current Reservoir Storage Level), which is just set in the course of the balance,
- a replenishment exceeding the current Reservoir Storage Level at the beginning of a month SIA and by this a refilling of the Reservoir in the considered month disadvantaging Users satisfaction is not possible,
- a desired lowering △ of the current Reservoir Storage Level SI only by an AB-element is not possible (only possible in connection with DYN-elements).

The regulation of releases by AB-elements enables a Reservoir management orientated on demand, which is economical thereby. However, it requires thoroughly reflections and the use of DYN-elements to translate the management plans into the „WBalMo-language“ in most cases. Also it is usually difficult to introduce a WBalMo-Reservoir regulation into operational practice. Such implementations require the integration of the whole balance algorithm of the WBalMo into an operational regulation model for the river basin and the connection to actual system state (current gauge data, Reservoir volumes, User withdrawals and return flows) (Dydymski, 2002). Only Reservoir releases set in advance or values calculated by functions can be reproduced using the mandatory release with ease.

4.3.6. DYN-Elements

Certain river basin management rules, registration requirements, as well as other necessary operations cannot be formulated by WBalMo standard elements. However, their consideration is possible by defining „Dynamic Elements“. The performance of the **standard algorithm** is interrupted by DYN-elements in order to process a given **individual** user algorithm. This algorithm in general contains relevant values of the **system state variables** and other **program variables**. The classification of DYN-elements takes place by their setting in the **ranking list** of all Users and Reservoir elements. In this way it is possible to select the moment of interruption of the standard algorithm.

Some examples for the application of DYN-elements are cited:

- **Setting variables of state** at the beginning of a realisation, a period or a year.
- **Calculating the evaporation loss** from Reservoirs depending on current Reservoir Storage Level and simulated potential evaporation.
- **Calculation of variable transfer quantities** depending on the discharge rate at the profile of withdrawal.
- **Registration of hydrographs** of relevant system states in individually defined dry periods.
- **Integration of models** for water balance calculations, flood management with time-steps < 1 month, calculating dependencies between ground water and Reservoir Storage Level or inclusion of water quality criteria in management.
- **Output** of selected values of state of WBalMo or values derived from them **into additional files**.

4.3.7. C-Field

The C-field can be used for the transfer of data, which do not match WBalMo dimensions, to DYN-elements and registrations.

In case of a WBalMo with balance period (chapter 4.1 Time Basis) a **period-depending** C-field consists of ANZP (= number of periods) vectors. The allocation is carried out separately for each period. Only one such vector is required for a WBalMo with one balance year

Examples:

- Capacities for transfers
- Surfaces of lakes for calculation of evaporation depending on simulated meteorological data
- Storage Level limits for Reservoirs, when by meeting their point of incidence special regulations come into force.

4.3.8. CC-Field

Data transfers between DYN-elements and registrations can be realised with **period-independent** CC-fields. The CC-field is designed in particular for data transfer via period borders. Therefore **no data input** / start settings exist as they do for the C-field.

Examples:

- Memorising of water levels and evaporation losses in Reservoirs for registration and utilisation in different DYN-elements
- Memorising of date of first time reaching full Capacity of new Reservoirs for output in special files
- Summation of different values (e. g. sums of releases of several Reservoirs subjected to determined uses) for registration.

4.4. Ranking List

As stated above (chapter 4.2 Balance) for WBalMo-elements „User“, „Release-Element“ and „DYN-Element“ a **rank** is to be specified, to enable the performance of the balance algorithm of WBalMo. This rank is a positive decimal number and may change within a year. It serves the **classification of each User into the system of Users as whole**. This number has no further significance. A low rank implies a higher priority concerning water supply. By this Users can be graded corresponding to their importance (e. g. supply of potable water prior to agricultural irrigation) in a **ranking list** with ascending ranks. Since this ranking list is worked out according to the balance algorithm in each simulation month, beginning with the lowest rank, „more important“ Users are first supplied with water.

The ranks do not always reflect a greater importance of the Users. If a balance according

to the rule „upstream Users prior to downstream Users“ is intended, the ranks of the Users must rise in the flowing direction of the respective river.

Example for priority water supply for industrial Users:

Element	Location upstream river mouth [km]	Name	Rank	Effect
...	...	...	...	...
N	8.9	Power station	24	Withdrawal of Power station
N	4.1	Industrial plant	30	Limited withdrawal possible
N	11.0	Irrigation	31.5	Possibly no withdrawal at all
...		...	...	...

Objective of the assignment of **ranks to Release-elements** of Reservoirs (AB-elements, AEND-element) is the reservation of a certain share of the current volume for a single User or a group of Users, respectively. In this way important utilisations can be supported by releases in dry periods, while other utilisations are already reduced or even cease. Therefore the rank of an AB-element with (low) minimum Storage Level is to set lower than the ranks of the Users to be supported. Users of lower importance can be excluded from supplies by a further AB-element with (higher) minimum Storage Level and a rank lower than of the Users to be balanced thereafter.

Also the replenishment of the Reservoirs is regulated by the ranks of the Release-elements. If a Reservoir is to be demanded more by different Users than another Reservoir, its AB-elements with (higher) minimum Storage Level and its AEND-element have to receive higher ranks than those of the competing Reservoir. The replenishment of the Reservoir (in the sense of balance) is then realised past the other Reservoir. For the Reservoir with higher rank there will occasionally be no or not sufficient water in the river basin for replenishment.

Example for different supplies by a Reservoir:

Element	Location upstream river mouth [km]	Name	Rank	Effect
...	...	...	...	...
AB[1.2]	8.9	Reservoir 1 with Capacity of 100 hm³	24.0	High releases caused by strong lowering to 10 hm³: share greater 10 hm³ is available
N	5.0	Power plant	24.5	Full withdrawal with high reliability in general
AB[1.3]	8.9	Reservoir 1 with Capacity of 100 hm³	30.0	Release limited by new minimum Storage Level of 80 hm³: only share greater 80 hm³ available
N	7.0	Irrigation	31.5	Withdrawal often limited by low Reservoir supplies
...		...	...	...

If a set release is to be always ensured by a Reservoir, this case is handled by a mandatory release in WBalMo.

Example of mandatory release of a Reservoir:

Element	Location upstream river mouth [km]	Name	Rank	Effect
...	...	...	...	...
AB[1.1]	8.9	Reservoir 1	1.0	Complete emptying of Reservoir 1 (minimum Storage Level = 0)

Element	Location upstream river mouth [km]	Name	Rank	Effect
...	>8.9	Balance of all Users upstream Reservoir 1	1.0 < Z < 24.9	
N	8.9	Balance of User of type Qmin	24.9	Mandatory release is „fixed“ (exceptions: Reservoir is empty or overloaded)
AEND[1]	8.9	End calculation of Reservoir 1	25.0	Maximal replenishment of Reservoir 1 under consideration of inflow and mandatory release
...	<8.9	Balance of all Users downstream Reservoir 1	Z > 25.1	

For particular requirements DYN-elements are available to enable the interference into the algorithm. Applications are, e. g., the inclusion of water transfers depending on the discharge rate or the inclusion of special Reservoir regulations. DYN-elements also receive a rank for the precise classification of their special algorithms into the sequence of WBalMo standard algorithms. If a DYN-element contains the calculation for a variable transfer, the rank of this DYN-element has to be lower than that of the User ‚transfer‘. The same procedure is to be carried out, if the minimum Storage Level of a Reservoir is calculated in a DYN-element. In this case of course the rank of the DYN-element has to be lower than that of the AB-element.

Example for the rank-classification of a DYN-element:

Element	Location upstream river mouth [km]	Name	Rank	Effect
...	...	...	...	...
DYN	-	Calculation of transfer maximal possible (ÜL) depending on discharge in km 9.5 and transit capacity of 2 m³/s	24	
N	9.5 (Main river)	Transfer from km 9.5 to tributary km 2.2	30	Transfer ÜL to tributary km 2.2
N	1.5 (Tributary)	Irrigation	31.5	Take for irrigation at tributary km 1.5

Summary for Effects of Ranks

At the beginning of a monthly balance all Users, AB-, AEND- and DYN-elements are classified into a ranking list with ascending ranks, respectively. The ranking list is then worked off gradually, beginning with the lowest rank:

If the element of the list is a **User**, its current demand is withdrawn from the discharge at the corresponding profile if possible. The withdrawal of other Users already balanced at this profile and profiles downstream is taken into account. Corresponding Release-elements or transfers are to be activated before, hence their rank has to be lower, if the support of the User is intended. The current possible withdrawal of the User (≤ demand) and thereby fixed returnflows cause changes in the discharge at the corresponding profile and all profiles downstream.

- A **Release-element** refers to a particular Reservoir and changes the availability of water stored within this Reservoir. The availability (release) is increased if the support of the Users following in the active list is intended. Otherwise the availability (release) is

decreased (example: a power plant is supported by Reservoir releases, an irrigation plant receives no Reservoir allowance). Reservoir releases change the discharge on all Balance Profiles located downstream.

- If the element of the list a DYN-element, the orders filed are realised. DYN-elements contain processes which cannot be performed by WBalMo standard algorithms in general (example: calculation of a Reservoirs evaporation dependent on current volume or transfers dependent on discharges).
- An AEND-element carries out a final Reservoir calculation. Taking into consideration User withdrawals downstream already balanced, the maximum possible quantity from inflow is being used to replenish the Reservoir. Water quantities exceeding the active Reservoir Storage Capacity are passed on as overflow in the lower reaches of the river. The Reservoir examined is no longer responsible for further Users in the current month.

Since in the simulating system WBalMo all changes of the system states are instantly carried out on all concerned profiles and variables of state, by working off the ranking list the natural discharge state of the basin is transformed gradually in each simulation month into the managed final state. Only this final state would be found in nature, if the basin would be regulated according to the rules integrated into WBalMo. Usually this final state is of interest only for registrations.

4.5. Registration

Each simulation of water utilisation processes in a river basin requires the registration of simulated system variables in order to be able to evaluate the quality of management variants. The registration includes frequency distributions, statistic numbers and extremes. Registrations of both variables of state and event durations is possible in WBalMo. Therefore three different types of registration tables exist.

4.5.1. Registration Type 1

Registration **type 1** concerns the **registration of variables of state** (number values); the result is the output of a table containing percentage exceeding frequencies or, in other words, reliabilities for values of a given registration list.

Examples:

Variable of state	Registration Term	**unit**	**Sorting list**
Storage Level of Reservoir 3 (size of active storage: 25 hm³)	SI[3]	hm³	2.5, 5.0, 7.5, 10.0, 12.5 ... 25.0
Discharge at Profile 27	X[27]	m³/s	0.5, 1.0, 1.5, 2.0, ... , 10.0
Relative satisfaction of the Users 8.4 requirements	100*AE[8.4]/E[8.4]	%	50, 60, 70, 80, 90, 100
Evaporation loss of Reservoir 3	CC(13)	hm³	0.1, 0.2, 0.3, ..., 1.0

4.5.2. Registration Type 2

The type 2 registration table enables the record of the duration of an event. The result is the output of a table of relative frequencies for the occurrence of events of fixed duration, events may begin in each calendar month.

Examples:

Event	Registration expression	**Sort list/strip [Month]**
Discharge falls below 5 m³/s at Profile 8	X[8] < 5.0*2.628 *)	1, 2, 3, 4, 5, 6
Current Storage Level exceeds 22.5 hm³ in Reservoir 3	SI[3] > 22.5	1, 2, 3, ... , 12

*) factor 2.628 serves the conversion of [m³/s] into WBalMo-internal unit [hm³/Mon]

4.5.3. Registration Type 3

With type 3, mean, standard deviation, minima and maxima of variables of state are registered. The values are separately calculated for each month and calendar year, respectively. The output takes place

- in case of a WBalMo on the basis of a balance year for this year,
- in case of a WBalMo on the basis of a balance period (for example 2003-2052)
  - for every individual year of the period (for example 2010, 2020),
  - for each period (for example 2003-2007, 2008-2012, 2013-2017) or
  - any requested fraction of time (for example 2003-2010).

Example similar to registration type 1.

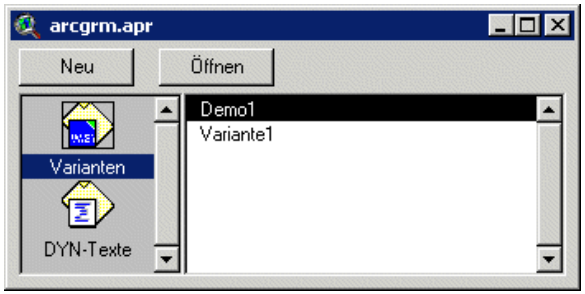
5 Kinds of Models and Application

5.1. WBalMo-Projects and -Variants

Each WBalMo-project is an **ArcView-project**. The file extension `*.apr` is linked as standard with ArcView and enables the start of ArcView and loading of project files by double clicking on the file icon in the File manager / Explorer, or opening the project from ArcView.

Project Window

The project window contains of a variant documents and DYN-texts. Furthermore document types available in ArcView can be opened via general program properties.



New

- creates a new variant

Open

- Variant documents (system sketches) highlighted in the list are opened.

New

- generates a new DYN-text.

Open

- opens highlighted texts in the project window.

Search

- starts the search for character strings in DYN-texts and DYN-elements.

Generating a WBalMo-Project

Project

Menu Project

New

- Confirm saving the modified „Base Project“
- Input a file name for the new WBalMo-project

Hint

From each WBalMo-project further projects can be derived. Variants contained in the „Base Project“ are not tranfered into the new project. Available DYN-Texts are taken over to the new project.

Save Project

Project

Variant

DYN-Text

Menu Project

Variant

DYN-Text

Save

Button

Save Project under a different Name

Project

Menu Project

Save as ...

Create List

Project

Menu Project

Create List

Button

5.2. Variants

The opportunity to compare **variants** with **model modifications of any size** is provided by WBalMo-projects.

- For the modelling of **nonstationary processes** (for instance changes in quantities for Users, Reservoir operation, natural yield with trends) for a fraction of time the variant is to be divided **into several periods**.
- For the examination of stationary processes one period is sufficient.

Access to data takes place by using „Variant“, derived from the ArcView document „View“. This type of document, among other things, serves the representation of the **system sketch**, which is either drawn up on the basis of an original scale background map or the relevant model elements of the investigation area in a rather abstract form.

- A separate directory exists for each variant file.
- All data belonging to a variant are filed according to a relational data model in dBase-files.

5.2.1. Create Variant

Project

Project Window

Variants

New

Menu Variant

New

Button

- Either
  - o a new, empty variant is generated or
  - o a variant of the project is copied.
- Input a directory for the variant
- Define properties of the variant

5.2.2. Loading Variants

Variants can be loaded into a project by selecting the directory containing the relevant shape- and dBase-files with the integrated browser. Accessible WBalMo variant-directories are marked with the WBalMo-Logo in the browser.

Hint

The number of the version (version 1 or 2) is displayed, if the variant (the directory) is opened by doubleclick.

While loading a version 1-variant the data are transfered to version 2.

The directories of the data series for the SSA are to be updated ocassionally.

Application

- Transferring / archiving files of a variant (whole variant-directory)
  - The files can be packed with a compression program if required, and subsequently be transferred or archived.
  - Loading variants is only possible for decompressed files.
- Opening a variant for processing from several work stations (note: no support for multi-user-access)

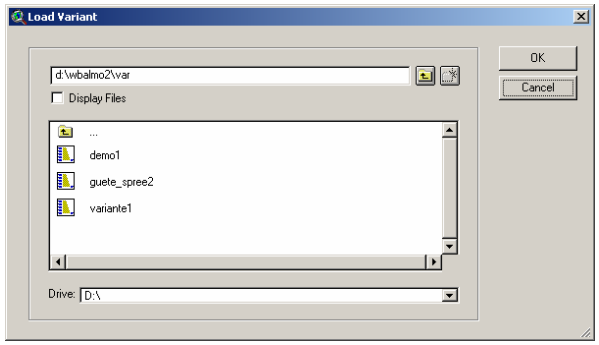
Project

Menu Variant

Load

Button

1. Select the variant to be opened (directory)
2. Confirm the selection with **OK**
3. Properties of dialog: confirm / arrange variants name



5.2.3. Importing Variants

Importing variants exported from version 1 (*.agv-files). From version 2 up the export-function is no longer supported. See chapter 5.2.2 Loading Variants.

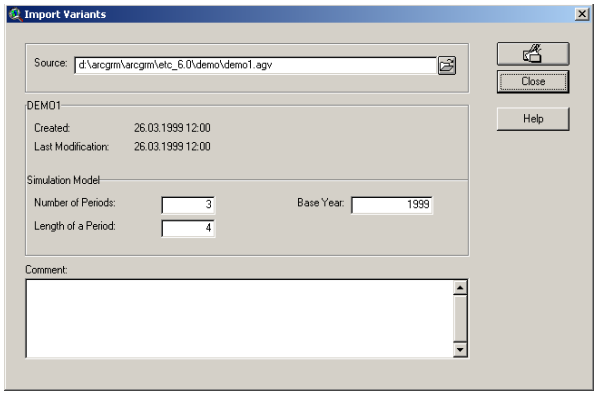
Project

Menu Variant

Import Variant

1. **Source:** Indicate path and file name with button
2. Start import with
3. Confirm **variant's name**; if a variant of the same name exists in the project, another name must be entered.

4. **Selecting a directory** for variant files.



Hint

The data are converted to version 2 while importing.

Also source files containing data series for the SSA are decompressed and filed into the variant directory.

The directories of the data series for the SSA are to be updated ocassionally.

5.2.4. Delete

Project

Project Window

Variants

Delete

- Select the variant to be deleted
- Confirm each variant to be deleted

Hint

Only the variant file references are removed from the project. Corresponding files and directories are to be physically deleted with the help of a data manager, e. g. Explorer.

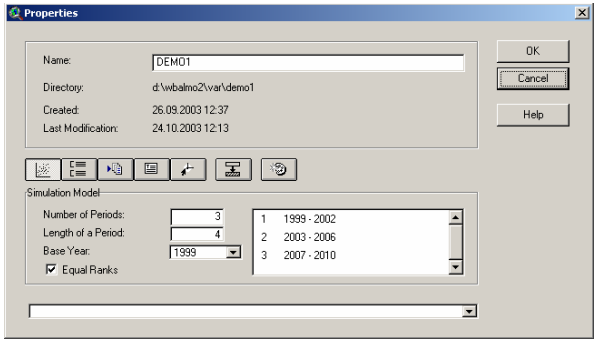
5.2.5. Properties

Variant

Menu Variant

Properties

Button



The **name** of a variant may be changed. An error message is displayed, if a variant of the same name already exists in the project.

Simulation Model

Enter the **number of periods** (≥ 1) as well as the **length of each period** (≥ 1 year) according to the underlying simulation model for the Simulation Sub Area series. Furthermore a **base year** (first year of the first period) is to be entered as reference for stochastic and deterministic data (User, Reservoir, Release-element).

- Transforming a model with one period into a model containing several periods (set LP, ANZP, base year)
- Transforming a model containing several periods into a model with one period (LP = 1, Selection of a base year)
  - Each starting year of a period of the previous model can become a base year
  - **Data from the last period of the previous model are assigned to Users (Z, E, R), Reservoirs (NG, Z(AEND), GR) and Release-elements (Z, G, BETA), respectively.**
- Changing the numbers of periods (reduction, extension)
  - The data specified for the previously last period are transferred to added periods (for example values of withdrawals/return flows).
  - **If the last period is deleted, data from the previously last period for Users (Z, E, R), Reservoirs (NG, Z(AEND), GR) and Release-elements (Z, G, BETA) are transferred to the new last period, respectively. Data are to be checked.**
- The length of a period once installed cannot be changed afterwards. The steps 2 and 1 can be carried out one after the other under consideration of the above restrictions.
- Modification of the base year
  - As (new) base year all starting years of the periods are permitted.
  - The extension "backwards" with a maximal of two periods of the past referring to the previous base year is also possible.

- The control box **Equal Ranks** is visible, if the model contains several periods.
  - Equal Ranks: the rank or the annual cycle of a rank arranged in the dialogues User, Reservoir or Release-element, respectively, in any period is automatically transferred to all other periods of this element.
  - If different ranks are applied in the periods, this control box will not be active.

Constants, Field Sizes

The sizes of the C-field and the CC-field (see chapter 5.3.13 DYN-Elements: System Variables, Procedures and Functions (Modelling) and chapter 5.3.18 Registration Terms: System Variables and Function) are fixed.

- If the C-field is increased, the added elements for all periods are occupied by zero values. While decreasing the C-field, already occupied elements are deleted after confirmation. This procedure cannot be reversed.
- The sizes of the CC-field may range between 100 and 2000 elements.

External Files, DYN-Texts

For the calculation of variants external files or DYN-texts of the project are available. DYN-texts are automatically stored in the active directory (standard: `$WBALMO2\TMP`) as ASCII-files of the same name before the start of the calculation. Declared external files are copied into this directory. The declaration of a directory for the file declaration is not necessary.

- In the list external files are assigned with the symbol , DYN-texts with , and unavailable objects with .
- By clicking the button the object selected in the list is deleted.
- An example for the use of this option is the supply of parameter files for DYN-elements regarding the run-time of the calculation.

Comment

It is possible to enter a comment describing the variant. This comment labels the variant for export / import, the report, and the result file of the calculation (in this case only the first five lines), respectively.

System Sketch – Raster Options

Elements of the system sketch: Balance Profile, Simulation Sub Area, User, and Reservoir, can be **aligned to a raster** by new definition and by editing the system sketch. This raster is defined

by **a zero point (X0, Y0)** and by the **gaps between the raster lines (dX, dY).**

Deleting unused Data Sets

For a number of dBase-files the data, are not physically deleted, to avoid instability in the program. Those data sets are only labelled „invalid“. The **compression** physically deletes all data sets labelled in this way. Subsequently the WBalMo program is closed. While starting WBalMo the next time a reinitialisation of all dBase-files is ensured. This function should be applied after reductions of larger extent.

Standard Legend

The legend used in the variant for Running Waters, Balance Profiles, Simulation Sub Areas, Users, and Reservoirs can be defined as a **standard legend**, respectively. The **system sketches** of all newly generated, copied and imported variants are represented according to this legend.

- By holding down the CTRL key the legend proposed by WASY is restored.

5.2.6. Print Preview and System Sketch Printing

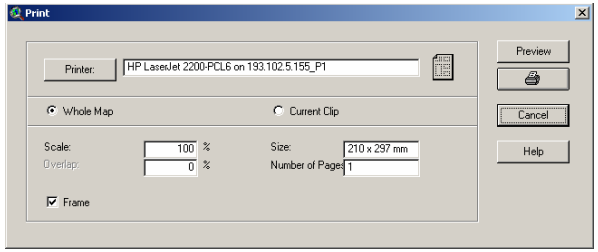
Print Preview and Printing

Variant

Menu Variant

Print

Button



Selecting and setting up a printer

- A **printer** can be selected from the available printers by the printer button. The selected printer can be set up via its software (paper format, resolution, colour options, etc).
- The name of the selected printer and the paper format is displayed: icon portrait / landscape with details on the **size** of the page [mm].

Details concerning the area to be printed

- Either the **whole map** or a **current section** of the system sketch can be printed or be observed as a print preview.

Page set up, establishing the zoom factor

- The set scale value refers to the use made of the adjusted page. The scale can be in the range of 1 ... 1000%. The **page number** resulting from the adjusted page size and the zoom factor is displayed.
  - Scale = 100: the area to be printed is projected and printed onto *one* page (pre-setting)
  - Scale < 100: the area to be printed is projected *smaller* corresponding to the zoom factor onto one page and printed onto *one* page
  - Scale > 100: the area to be printed is projected *larger* corresponding to the zoom factor onto one page and printed onto *several* pages. The **number of pages** resulting from the zoom factor is displayed.
  - Example Scale = 220: the area to be printed is projected onto one page and is scaled by a factor of 2.2 afterwards. The number of pages = 6.
- If the printout requires several pages, an **overlap factor** can be set. The possible overlap of the page margin is in the range of 0 ...50%.

Further Options

- Alternatively each map can be printed with a border.

Print Preview

- By operating the **preview** button the adjustments, established above, for printing are represented (position and size of the page(s), overlap of the page margin) in the system sketch.
- The views / system sketches zoom factor is calculated and adjusted, as it results from the selected printing medium. Thereby it is possible to establish the optimal page size and the format for the system sketches actual extent and its labelling. Furthermore the size of labels in the system sketch printout can be checked on the screen.

Starting the printing process

- A possible existing print preview is to be deleted.
- By clicking the print button printing with the options set is activated.

Delete Print Preview

Variant

Menu	Graphic
	Delete Print Preview

5.3. Data Classes

5.3.1. Overview

The data necessary for the structure of a river basin management model with established management strategies are divided into the following **data classes**:

- Running Waters (Rgw)
- Balance Profile (Bp)
- Simulation Sub Area (SSA)
- User
- Reservoir
- Release-element
- C-field
- CC-field
- Dynamic-element (DYN-element)
- registration type 1
- registration type 2
- registration type 3

Dependencies of the Data

The order stated above corresponds to the sequence of a WBalMo variant-structure. There are several compelling conditions:

Data Classes	Based on the existence of
Balance Profile	Running Waters
User	Balance Profile
Reservoir	Running Waters
Release-Element	Reservoir
DYN-Element	Running Waters
Registration 1 || 2 || 3	Running Waters

Note: objects can only be **deleted,** when no elements of other data classes are based on them. It is only allowed to delete Running Waters, when neither Balance Profiles nor Reservoirs are situated on them.

Selecting and Editing Data

Model elements with geographical coordinates

- Running Waters, Balance Profiles, Simulation Sub Areas, Users, and Reservoirs are represented in the form of a **system sketch**, respectively.
- Definition **of new** elements
  - The corresponding tool Running Waters , Balance Profile , Simulation Sub Area , User or Reservoir is active. The first mouse button determines the position in the system sketch whilst

simultaneously holding down the SHIFT key. Subsequently relevant object data can be entered into a dialogue mask.

- Access to **existing** elements
  - The corresponding tool is active. By clicking on the object of interest in the system sketch with the first mouse button the corresponding object data are displayed and can be edited.
  - Opening the data class of interest via menu, subsequently select an element within the data class (name, code number or scrolling)
  - Select an object in the navigator

Model elements without geographical coordinates

- The classification of (not represented) Release-elements, C-field, DYN-elements and registrations type 1, 2, 3 takes place automatically by the currently opened system sketch / variants
- Definition of **new** elements, if no elements of this type exist
  - Activate the corresponding button or menu register in "Data Class", subsequently select an element via name or code number
  - Select an object in the navigator
- Define **new** elements, if elements of this type already exist
  - Activate the button new in the dialogue of the requested data class.
- Access existing elements
  - Selec an element within the data class via name, code number or scrolling
  - Select an object in the navigator

Selecting a Period

Dialogues User, Reservoir, Release-element, C-field

Period data are displayed in a dialogue. The selection takes place via its **period number**, **last year of validity** or via **scrolling**.

Copying and Inserting

Dialogues User, Reservoir, Release-element, C-field

- Button
  - **All** period-dependent values of the current period of a model element are copied into all other periods **of the same element**.

- Button
  - o **All** period-dependent values of the current period of a model element are copied into the **Clipboard**.
- Button
  - o The values from the clipboard are inserted into the current model elements period, provided that the contents from the **clipboard** comes from an element of the **same data class**.

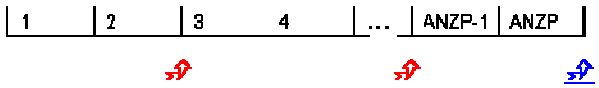
Undoing Data Changes

Dialogues Running Waters, Balance Profile, User, Reservoir, Release-element, DYN-element, registration type 1, registration type 2, registration type 3

- Button

5.3.2. Period

- The ‚**Validity Windows**‘ of deterministic data for Users, Reservoirs, and Release-elements, respectively, can be **individually** established under consideration of the variant simulation models **period limits** . The entered data are valid until the next defined model element period limit **of this** model element.
- If no limits are set, the entered data are valid up to and including the end of the last period .
- Available variant period limits

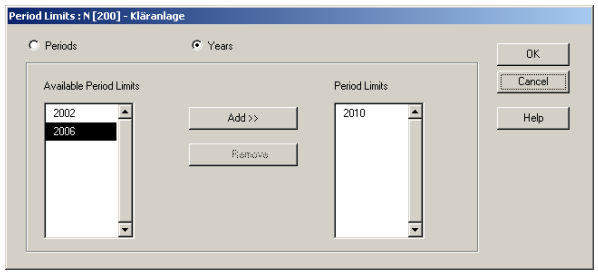


Validity window **of a** model element (Example)

Establishing the Validity Windows of a Model Element

Dialogues User, Reservoir, Release-element

- Button



- Alternately **period numbers** or **year numbers** are displayed, which mark the end of the relevant period.
- By activating the **add** button a selected value moves from the **available period limits** list

into the used period limits list (validity window).

- **Remove** deletes the selected value from the **period limit list**. Deletion of the last period limit is not possible.

5.3.3. Navigator

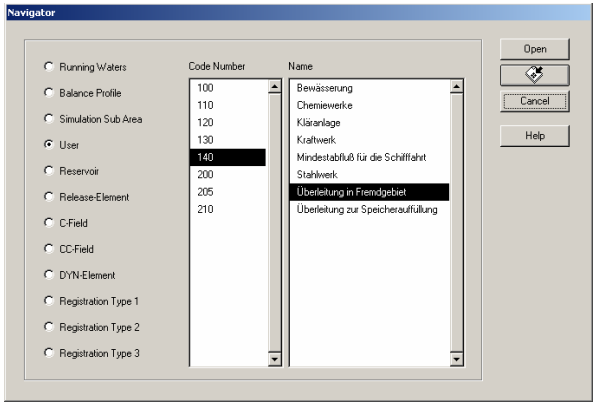
All variant model elements are displayed in the WBalMo-Navigator. It allows existing data to be opened, system sketch elements to be localised or model elements to be redefined.

Variant

Menu Data Classes

Navigator

Button



Selecting a Data Class by activating a Control Box

- Running Waters
- Balance Profile
- Simulation Sub Area
- User
- Reservoir
- Release-element
- C-field
- CC-field
- DYN-element
- registration type 1
- registration type 2
- registration type 3

If the data classes Release-element, C-field, CC-field, DYN-element, registration type 1, registration type 2 or registration type 3 contain no elements, a new definition or initialisation is possible by the buttons , , , , , and , respectively. In other cases these buttons are not visible.

Selecting an Element by its Code Number or Name

- Button **OK** opens the dialogue of object data of the element

- Button of the element in the system sketch
  - o **Running Waters, Simulation Sub Area:** the visible section and the system sketch scale are established in a way that the chosen element is completely visible.
  - o **Balance Profile, User, Reservoir:** The chosen element is located in the centre of the visible section. The scale is not changed.

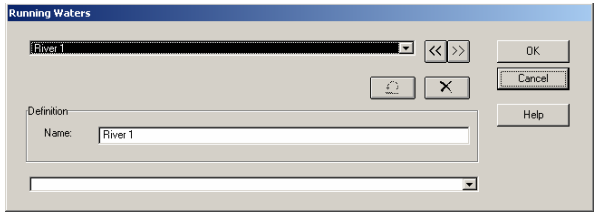
5.3.4. Running Waters (Rgw)

The **structure of the model** is defined by Running Waters. The **direction of drawing** is interpreted as the **direction of flow**. Relevant Balance Profiles and Reservoirs can be put on these Running Waters represented by lines.

Since at the moment editing of the system sketch contains **no functions to modify the model structure** (i. e. changing the direction of flow, dividing or extending a track, additional establishment of river mouths, etc.), these works need to be carefully considered and conscientiously carried out.

Variant

Menu	Data Classes	
		Running Waters
Tool		



New Definition

- The line is drawn (as polygonal draft) while **holding down the SHIFT key** – the bases are allocated by clicking the mouse button. A line is completed by **double clicking**.
- **River mouths** are entered by putting the last point of a tributary onto the (main) river.

Attributes

Name

- Maximum of 60 alpha numeric characters
- If no name is entered, an automatic name assignment is carried out, in order to enable the navigation within this data class.

Delete

- Button

Running Waters are allowed to be deleted if no Balance Profiles or Reservoirs are located on them.

Hint

Be careful when deleting main rivers, the mouths of the tributaries will be likewise automatically deleted.

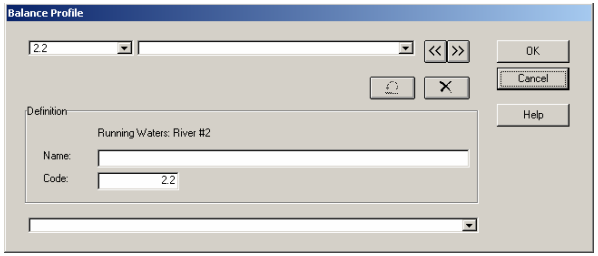
5.3.5. Balance Profile (Bp)

Variant

Menu Data Classes

Balance Profile

Tool



New Definition

- The location of a Balance Profile on Running Waters is marked by the mouse while **holding down the SHIFT key** .
- The location of a Balance Profile can be changed subsequently only in the sector of the Running Waters segment once established.

Attributes

Name

- Maximum of 60 alpha numeric characters

Code Number

- Decimal number in the interval of 0.0001 ... 99999.9999 with a maximum of 6 significant figures
- Clearly marked within that data class

Running Water

- The name of the Running Water the Balance Profile is located on, is displayed.

Delete

- Button

When a Balance Profile is neither a Users withdrawal profile or a return flow profile it may be deleted.

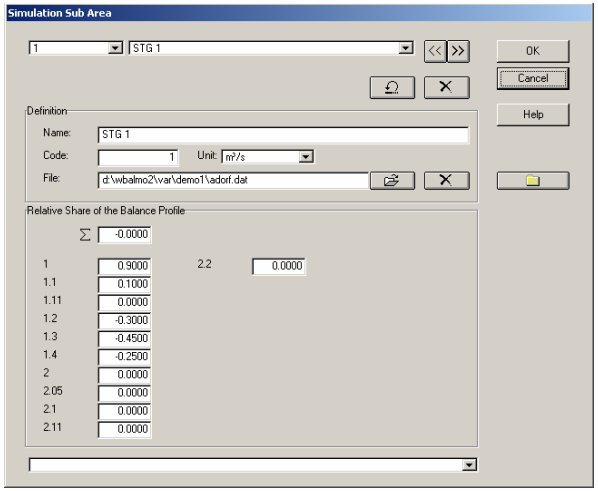
5.3.6. Simulation Sub Area (SSA)

Variant

Menu Data Classes

Simulation Sub Area

Tool



New Definition

- It is necessary to draw a **polygon** with the mouse, enclosing concerned Balance Profiles, to indicate on which Balance Profiles the natural yield is to be divided. The first vertex point is to be set whilst holding down the SHIFT key. In addition the user has to select all profiles which have a negative share on this SSA.
- A **point** (Shift + double-click) serves as wild card for other series, for example precipitation or evaporation of an area. No division of the natural yield takes place on a Balance Profile.

Attributes

Name

- Maximum of 60 alpha numeric characters

Code **Number**

- Decimal number in the interval of 0.0001 ... 99999.9999 with a maximum of 6 significant figures
- Clearly marked within that data class

File

- Establishing a file takes place by clicking on , the file can be deleted by clicking on .
- Applying of the same file for more than one SSA is not permitted. In this case the numbers of the SSA trying to access the same file are displayed.
- A variant calculation is only possible, if a data series has been assigned to each SSA.
- Via the button it is possible to change the directories for several data series. The selection of a single file within this directory is sufficient. The path previously active is kept for those SSA, whose file is not located in the new directory.

- The selected file has to be an ASCII-file with a table of numbers.
  - Decimal separator ".", columns are separated by a space, tabstop or comma
  - 12 columns January ... December
  - The lines are chronological sequences of the years of each realisation, in the case of a balance year the sequences of this single year.

Unit

- Series of natural yield (discharges from river basins), SSA drawn as polygon
  - Standard units: m³/s, hm³/Mon, l/s or 1000 l/d
  - User specific quantity units of the variant
- Simulated series, SSA drawn as point
  - Beside the above quantity units also units with no references to quantities of the variant are at disposal.

Relative share of Balance Profiles

- Decimal number in the interval of -9999.9999 ... 99999.9999
- The actual sum of the shares of all profiles at this SSA is displayed after data changes.
- If a SSA contains more than 30 Balance Profiles, it is possible to scroll with and . Otherwise these buttons are not visible.
- The relative shares of new Balance Profiles at the SSA can be entered by opening the corresponding SSA. The shares of all previous Balance Profiles has to be checked. This is also the case for deleting Balance Profiles.

Delete

- Button

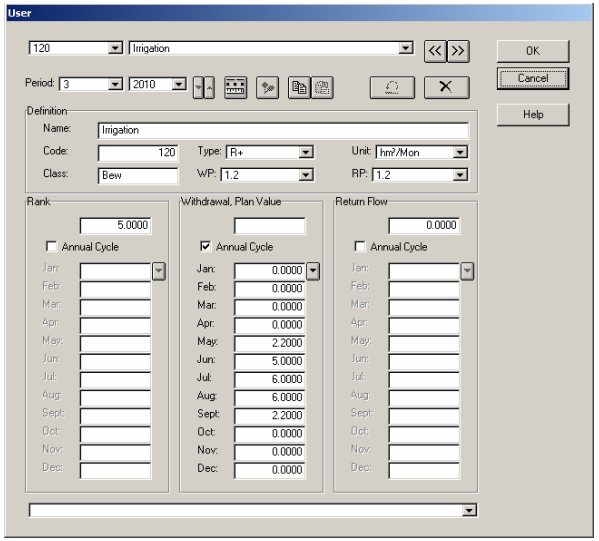
5.3.7. User

Variant

Menu Data Classes

User

Tool



New Definition

- By clicking **the first mouse button** whilst holding down the **SHIFT key** the location of the User is marked in the system sketch.
- The Users' (geometric) location is arbitrary and stands only in indirect correlation with its withdrawal and return flow profile. For better visualisation of the User it should be entered either in proximity of its withdrawal or return flow profile or in proximity of its geographically correct location in the system sketch.
- The Users' location can be changed by editing the system sketch.

Attributes

Name

- Maximum of 60 alpha numeric characters

Code **Number**

- Decimal number in the interval of 0.0001 ... 99999.9999 with a maximum of 6 significant figures
- Clearly marked within that data class

Class

- Maximum of 5 alpha numeric characters
- The class of Users can be displayed with an individual legend in the labelling of the system sketch.
- In the ranking list the **class** is displayed as commented attribute.

Type

- Select from **R** (withdrawal and return flow), **CR** (only return flow), **Qmin** (minimum discharge), with availability of return flow for lower rank Users on the return flow profile (**R+**, **CR+**), or unavailability (**R-**, **CR-**), respectively

Units for withdrawal and return flow

- Standard units: m^3/s, hm^3/Mon, l/s or 1000 l/d
- User specific quantity units of the variant

Withdrawal profile, return flow profile

- Selecting a Balance Profile
- The return flow profile may not lie above the withdrawal profile for User types R+ and R-

Withdrawal and return flow quantities

- Decimal number in the interval of 0... 99999.9999
- For User types R+ and R- is valid:
  - o $E > 0 \Rightarrow 0 \leq R \leq E$
  - o $E = 0 \Rightarrow 0 \leq R \leq 99999.9999$
- Annual cycle possible
- Variable within periods

Hint

Possibilities for definition of users (withdrawal and return flow quantities):

Entering of (static) values in the dialogue

- permission by water rights,
- planning data

Calculation for run-time of the model in DYN-elements depending on other system states

- Irrigation = f (N, PET)
- Fishery = f (PET)
- Transfer = f (Q)

Rank

- Decimal number in the interval of 0.0001 ... 99999.9999
- Annual cycle possible
- Variable within periods

Delete

- Button

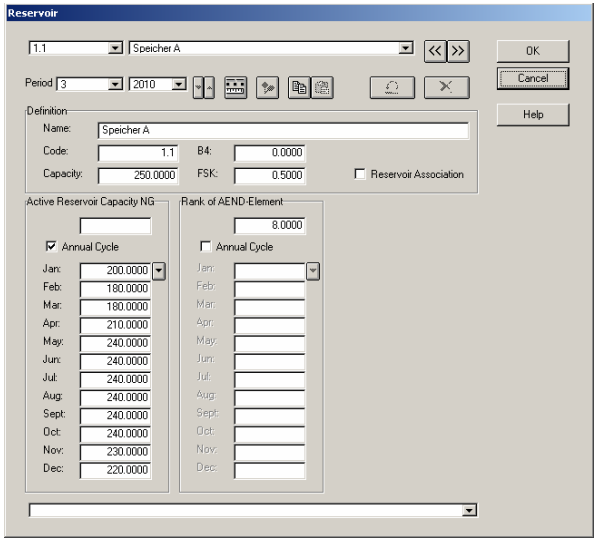
5.3.8. Reservoir

Variant

Menu Data Classes

Reservoir

Tool



New Definition

- The location of the Reservoir on Running Waters is established by clicking the first mouse button whilst **holding down the SHIFT key** in the system sketch.

Attributes

Name

- Maximum of 60 alpha numeric characters

Code Number

- Decimal number in the interval of 0.0001 ... 99999.9999 with a maximum of 6 significant figures
- Clearly marked within that data class

Capacity SK [hm³]

- Maximum Active Storage Capacity within a year
- Decimal number in the interval of 0.0001 ... 99999.9999

Starting Storage Level FSK

- **FSK • NG** = Reservoir Initial Storage Level at the start of the calculation
- Decimal number in the interval of 0 ... 1

Reserve variable B4

- Decimal number in the interval of -9999.9999 ... 99999.9999

Active Reservoir Capacity NG [hm³]

- Size of Active Reservoir Storage (monthly dependent) IBR or R_3
- Decimal number in the interval of 0.0001 ... 99999.9999
- Active Reservoir Capacity NG $\leq$ Capacity SK
- Annual cycle possible
- Variable within periods

Rank of the AEND-element

- Decimal number in the interval of 0.0001 ... 99999.9999
- With associated management no other elements are allowed to be filed with their ranks between the ranks of an Associations AEND-elements. An examination via the ranking list is possible.
- Annual cycle possible
- Variable within periods

Reservoir Association

Number of Reservoir Association

- A whole number in the interval of 1 ... 128
- Create **new** Association or **change** data of an Association
  - After activating the control box **Write**, the desired Associations number is to be entered.
  - If this Association does not exist in the active variant, a new Reservoir Association is set up. In other cases the entered values for IGR and ING (see below) are adopted for all Reservoirs in the Association.
- **Assign a Reservoir to an existing** Association
  - By activating the control box **Read**, the existing associations are displayed with its Reservoirs. The corresponding Association is to be chosen from this list.
  - The Association number, IGR and ING cannot be edited in Read mode. When required, **Write** is to be activated.

Limit Value GR [hm³]

- Subdivision of Active Reservoir Capacity NG into 2 shares
- Decimal number in the interval of 0 ... 99999.9999
- Limit GR $\leq$ Active Reservoir Capacity NG
- Annual cycle possible
- Variable within periods
- The limit at the beginning of each month is set on the current Reservoir Storage Level value if GR = 0.

IGR

- Number of slices for the 1st replenishment stage up to GR
- A whole number in the interval of 0 ... 128
- IGR = 0 means, that the 1st stage is not taken into account (no subdivision of the free storage by GR).

ING

- Number of slices for the 2nd replenishment stage up to NG

- A whole number in the interval of 0 ... 128
- ING = 1 denotes the interruption of proportional replenishment of the 2 stage. It is replaced by replenishment according to the ranks of the AEND-elements of the Associations Reservoirs.

Rank of the AEND-element

- With associated management no other elements are allowed to be arranged with their ranks between the ranks of an Associations AEND-elements. An examination via the ranking list is possible.

Delete

- Button

A Reservoir may not be deleted as long as Release-elements are assigned to it.

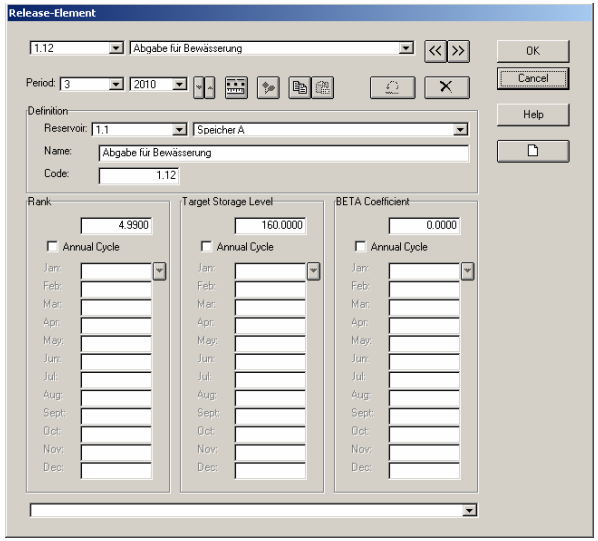
5.3.9. Release-Element

Variant

Menu Data Class

Release-Element

Button



Attributes

Reservoir

- The assignment of a Release-element to a Reservoir takes place by selecting the corresponding Reservoir from the list of code numbers or the list of names of all Reservoirs.

Name

- Maximum of 60 alpha numeric characters

Code Number

- Decimal number in the interval of 0.0001 ... 99999.9999 with a maximum of 6 significant figures
- Clearly marked within that data class

Rank

- Decimal number in the interval of 0.0001 ... 99999.9999
- Annual cycle possible
- Variable within periods

Target Storage Level G [hm³]

- Decimal number in the interval of 0.0001 ... 99999.9999
- Target Storage Level G ≤ Reservoir Capacity NG
- Annual cycle possible
- Variable within periods

BETA Coefficient

- **BETA • SIA** = Target Storage Level
- Decimal number in the interval of 0 ... 1
- Annual cycle possible
- Variable within periods

5.3.10. C-Field

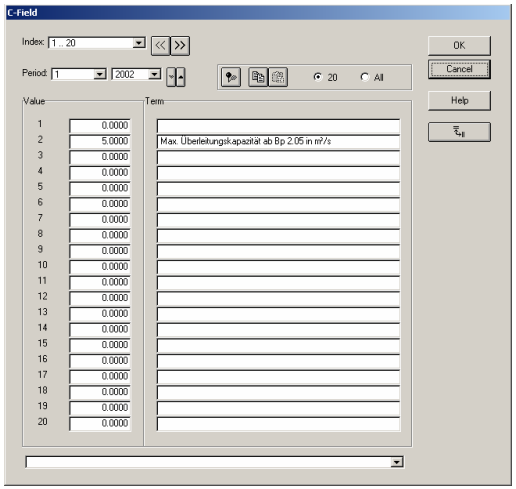
- The size of the C-field is set in the properties of the variant. The default value of the elements is equal to zero.
- The C-field has no dimension.
- Utilisation
  - o Values entered in the dialogue can be read in DYN-elements and registrations
  - o Writing access in DYN-elements, application of these results in other DYN-elements and registrations

Variant

Menu Data Classes

C-Field

Button C



Attributes

Value

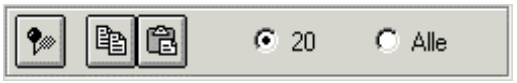
- Decimal number in the interval of -9999.9999 ... 99999.9999

- Variable within periods

Description

- Maximum of 60 alpha numeric characters

Clipboard Functions



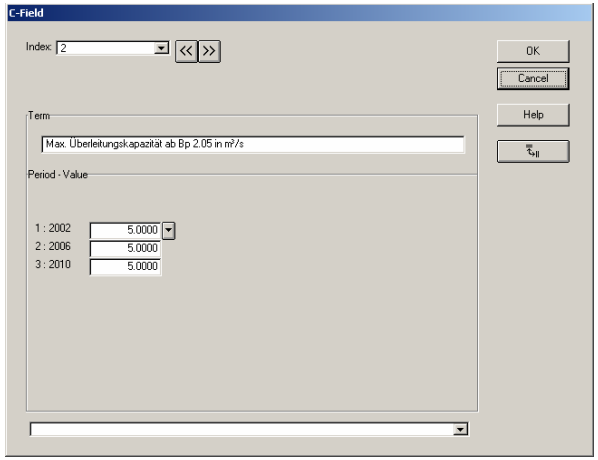
- Transfer of the **20** visible values or all values **(all)** to the same elements in other periods with the button . This process **overwrites** existing numbers.
- Copying of element values with the button and pasting into the selected (visual) periods with the button according to the active setting **20** or **all**

Changing the View

With the button the view of the C-field elements can be changed:

a) Values of C-field elements for the same period are displayed (see above)

b) Values of an element for different periods are displayed.



Hint

While using C-Field-Indices in DYN-elements, especially calculated ones, the size of the field is to be regarded.

The C-Field is of the type REAL(4).

5.3.11. CC-Field

- The size of the CC-field is established in the properties of the variant. The default value of all elements is equal to zero.
- In contrast to C-fields the CC-field is not dependent on periods.
- A dialogue-based occupation for data-elements of the CC-field by the user is not

possible. The dialogue contains a list of comments for program-/model internal use of the CC-field elements for the documentation of the variant.

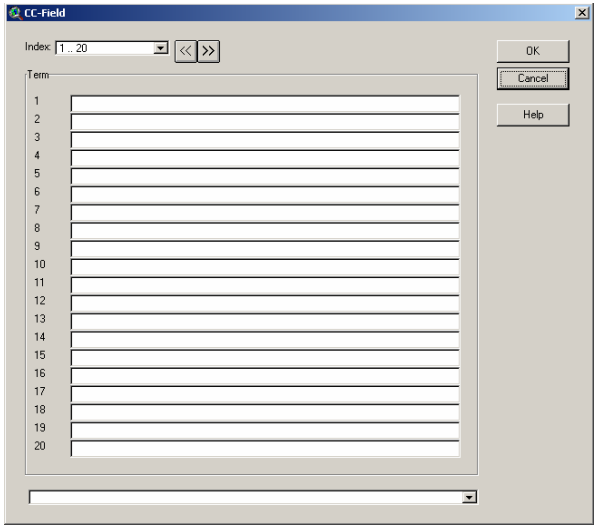
- Utilisation
  - o Writing access in DYN-elements, application of these results in other DYN-elements and registrations

Variant

Menu Data Classes

CC-Field

Button



Attributes

Description

- Maximum of 60 alpha numeric characters

Hint

While using CC-Field-Indices in DYN-Elements, especially calculated ones, the size of the field is to be regarded.

The CC-Field is of the type REAL(4).

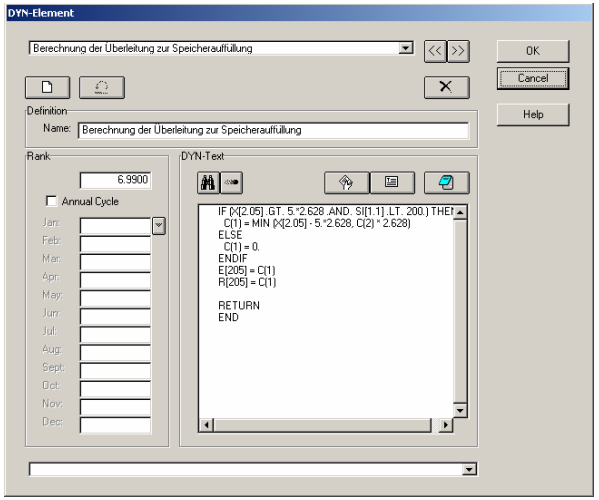
5.3.12. DYN-Elements

Variant

Menu Data Classes

DYN-Element

Button



Attributes

Name

- Maximum of 60 alpha numeric characters

Rank

- Decimal number in the interval of 0.0001 ... 99999.9999
- Annual cycle possible

DYN-Text

- DYN-text (FORTRAN-source code) is to be entered in accordance with FORTRAN conventions. The use of available software variables, procedures and functions, as well as self declared local and global variables, is possible.
- References to model object attributes (discharge rate at a Balance Profile, Reservoir Storage Level, User return flow, etc.) takes place by using the associated number in brackets, e. g. X[1.2], E[4.11] or SI[3.0].
- The initial entered value of a User E or R (without annual cycle), or of a variable without annual cycle NG, G, GR or BETA is lost, if the respective value is overwritten in a DYN-element. To avoid this fact, parameters have to be entered with annual cycle and 12 similar values into relevant data classes. The simulation program can check overwriting of these annual values.
- The exchange of information between DYN-elements takes place via
  - Pre-defined fields C and CC,
  - In modules such as "public" self defined global variables as well as
  - COMMON-blocks.
- For the integration of routines (subroutines and functions) a number of possibilities are available:
  - Entry of the functions texts directly behind the DYN-text
  - Utilisation of functions implemented in modules

- Inclusion of binary functions in DLL-files. These may also be developed in languages other than FORTRAN.

- If files are read or written in DYN-texts, the complete path name should be given in the source code. Otherwise the relevant files are searched for in the TEMP-directory and in the PATH-variable directory. The storing of files takes place in the TEMP-directory

Search for a character string in the DYN-text

Continue searching for this character string

Add DYN-text contents to cursor position

Save text as DYN-text

Starts the **external editor** (chapter 2.6 Option). The text window in the dialogue DYN-element is mainly for the display of DYN-texts. The text can be edited there, but the edition of texts should rather take place in the integrated editor DYN-text or an external editor for more comfortable handling. WBalMo waits until the external program is closed, the utilisation of several opened files at the same time is not supported. The editor loads the current DYN-text automatically (as file). While closing the file, the (changed) text is written into the dialogue. The closing of the file takes place before another file is opened in the same window!

For text editing the following Windows key definitions are also available for clipboard operations:

- CTRL C to copy highlighted text into the clipboard
- CTRL V to insert the contents of the clipboard in place of the highlighted text or in accordance with the relevant cursor position
- CTRL X to cut and store the highlighted text into the clipboard

Example

For Reservoir S27, with code number 27, the evaporation loss is to be modelled by correcting the current Storage Level SI[27.0], using an established formula at the start of the month:

- Winter (months 1 - 4,10 -12) evaporation = 0.0006 * SI
- Summer (months 5 - 9) evaporation calculation by utilisation of FORTRAN-FUNCTION „EVAPOR“.

Name:

SV_S27

Rank:

0.0001, valid for 12 months

The rank has to be lower than the ranks of all other elements due to consideration before all other balances.

DYN-Text:

```
IF ((MON .LT. 5) .OR. (MON .GT. 9))
THEN
  C(8) = 0.0006 * SI[27]
ELSE
  C(8) = EVAPOR (MON, SI[27])
END IF
SI[27.0] = MAX (SI[27] - C(8), 0.)
END

REAL FUNCTION EVAPOR (m, si)
INTEGER(2) m
REAL(4)    si
REAL(4)    F
F = ABS (m - 7.5) * 0.375
EVAPOR = 0.0006 * si / F
END
```

5.3.13. DYN-Elements: System Variables, Procedures and Functions (Modelling)

See also chapter 5.3.14 DYN-Elements: Procedures for Program.

Available Program Variables

Object	Variable	Unit	Meaning	Art
	ANZR		Number of Realisations	Z, L
	NREL		Serial number of current Realisation (1...ANZR)	Z, L
	ANZP		Number of Periods	Z, L
	NPER		Serial number of current Period (1...ANZP)	Z, L
	LP		Period length in years	Z, L
	JAHR		Simulation year within a Period (1...LP)	Z, L
	MON		Current Month (1...12)	Z, L
C-Field	C (i)		Period-related field of variables of type REAL(4)	D, LS

Object	Variable	Unit	Meaning	Art
	CC (i)		Period-independent field of variables of type REAL(4)	LS
Balance Profile	X [Bp]	hm³/ month	Discharge	Z, LS
	XS [Bp]	hm³/month	Protected Discharge	Z, LS
Simulation Sub Area	Q [SSA]	hm³/ Month	Natural Yield	Z, L
Simulated Series	Q [SSA]	free	Model-dependent	Z, L
User	E [N]	hm³/ Month	User Demand (planned value)	D, LS
	R [N]	hm³/ Month	Return Flow (planned value)	D, LS
	AE [N]	hm³/ Month	Actual Withdrawal	D, LS
Reservoir	SK [S]	hm³	Reservoir Capacity	D, L
	NG [S]	hm³	Active Reservoir Capacity	D LS
	GR [S]	hm³	Number of Reservoir slices in case of associated operation	D, LS
	B4 [S]		Reserved Variable	D, LS
	SIA [S]	hm³	Reservoir Storage Level at the start of the month	Z, LS
	SI [S]	hm³	Reservoir Storage Level during or after the calculation in the time-step of a month	Z, LS
Release-Element	G [Ab]	hm³	Target Storage Level	D, LS
	BETA [Ab]		Coefficient for calculation of Target Storage Level (G) depending on SIA	D, LS

i Index of a C-field-or CC-field-element
Bp Number of a Balance Profile
SSA Number of a **Simulation Sub Area**

N Number of a User
S Number of a Reservoir
Ab Number of a Release-element
D Variable of Definition
Z Variable of State
LS Reading and Writing Access
L Reading Access

Available Procedures and Functions

CALL CHXX ([Bp1], [Bp2], delta)

- Changes the discharge rates on all Balance Profiles from Bp1 in direction of flow up to and including Bp2 by the quantity of delta.
- CHXX is applied to the end of the current track by entering of „-999“ into Bp2.

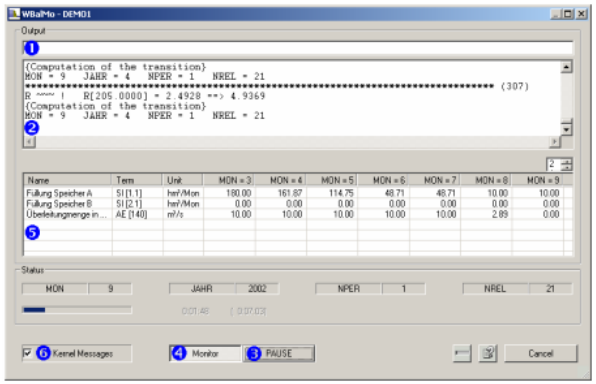
flamelle = FREI ([Bp1], [Bp2])

- Calculation of the smallest available volume flamelle on all Balance Profiles from Bp1 in direction of flow up to Bp2. The discharge rate in the section between Bp1 and Bp2 is allowed to be reduced by this value, without impairing utilisations, which have already been balanced.
- If Bp2 is set as „-999“ the smallest available volume flamelle to the end of the whole track is calculated.

5.3.14. DYN-Elements: Procedures for Program Control

See also chapter 5.3.13 DYN-Elements: System Variables, Procedures and Functions (Modelling).

FORTRAN-commands WRITE (conout$) and PAUSE (conout$) as well as other console commands are not available as standards. Instead implemented emulations of the Windows program should be used. The use of the above commands is possible by explicit initialisation of the console.



Available Procedures

Writing in Display-Window "1"

- The displayed information consists of one line, that means each output overwrites the preceding.

```
character(255) :: string
call write0(string)
```

Writing in Display-Window "2"

- The texts are written as protocol continuously.
- With active monitor, while PAUSE as well as at the end of the simulation, the whole text is displayed. Otherwise only the last output is visible.
- Beside "write1"-outputs from DYN-elements also Kernel-messages are written inside this window, as long as it is activated ("6"),.

```
character(255) :: string
call write1(string)
```

Activating the PAUSE function ("3")

- The program can be activated by pressing the button or by invoking of "PAUSE_" from DYN-elements.
- Text output takes place in **Display-Window** "2".
- Continuation of the program is only possible by releasing the button.

```
character(255) :: string
call pause_(string)
```

Message Box

Depending on argument i, a Message Box with any text is displayed.

- Error i<0
  - After closing the Box the program is terminated.
- Warning i=0
  - If the Box is closed by "interrupt", the program is terminated, otherwise continued.
- Information
  - After closing the Box the calculation is continued.

```
integer(2)     :: i
character(255) :: string
call MsgBox(string,i)
```

Monitor "4"

- Depending on argument (.TRUE. or .FALSE.) the monitor "5" is switched in or switched off.

```
logical(1) :: bool
call monitor_(bool)
```

Kernel warnings "6"

- If the simulation was initialised with option "Messages GRM-Kernel", checking and possibly resulting outputs of warnings occur until the mode is quitted in window "1" (argument = .FALSE.).

```
logical(1) :: bool
call debuginfo_(bool)
```

Initialise Console

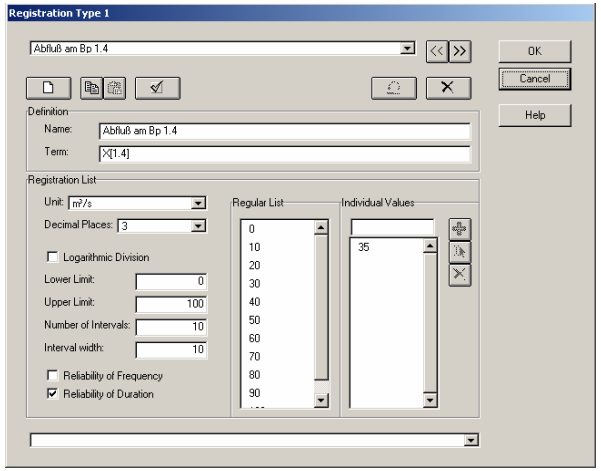
- After the initialisation routine it is possible to access a Windows-console for instance by WRITE(*,*), READ(*,*), and PAUSE, respectively.
- The console is available for all program units (DYN-elements, modules, DLL-functions). The initialisation is to be guaranteed before the first access.
- If the console-window is closed, the simulation is interrupted without asking for confirmation.

```
call init_console
```

5.3.15. Registration Type 1

Variant

Menu	Data Classes Registration Type 1
Button	1



Attributes

Name

- Maximum of 60 alpha numeric characters

Arithmetic term

- The arithmetic term defines the value to be registered by utilisation of available program variables and functions, parenthesis, as well as mathematical and numeric functions in accordance with the used FORTRAN-compiler. The reference to model object attributes (Balance Profile discharge, Reservoir Storage Level, User return flow etc.) takes place by using the corresponding number in brackets, e. g. X[1.2], E[4.11] or SI[3.0].
- A term may be up to 255 characters long.

Selecting a unit

- Standard units m³/s, hm³, 1000 m³/d, l/s, hm³ or %
- Further available units

Choosing the number of significant figures for the registration list

- 2 ... 5

Logarithmic or linear subdivision of the registration list

Lower and upper limits of the registration list

- Decimal numbers in the interval of -9999.9999 ... 99999.9999
- Lower Limit LL < Upper Limit UL
- In addition with logarithmic subdivision: Upper Limit UL > 0

Interval number of the registration list defined by lower and upper limits

- 1 ... 256

Interval width

- Interval width cannot be entered and is only displayed.
- The interval width is calculated for linear registration lists as

$$Width = \frac{UL - LL}{Intervals}$$

- And with logarithmic registration lists as

$$Width = \left(\frac{UL}{LL}\right)^{\sqrt[Y]{Intervals}}$$

Registration of reliability according to frequency

- Reliability according to frequency results from the relationship of the years y, in which the registration size value is achieved or exceeded in all months, to the total number of the simulated Years Y.

$$SH = \frac{j}{J} \cdot 100$$

Registration of reliability according to duration

- Reliability according to duration results from the relationship of the months m, in which the registration size value is achieved or exceeded in all months, to the total number of the simulated Months M.

$$SD = \frac{m}{M} \cdot 100$$

Regular list

- A preview is generated from details of lower and upper limits, interval numbers and the number of significant figures, as well as the alternative selection of logarithmic or linear subdivision. Up to 50 elements are displayed.

Individual values

- Individual values can be produced in addition to regular registration lists values.
- Decimal number in the interval of -9999.9999 ... 99999.9999
- Add individual value
- Overwrite selected individual value
- Delete selected individual value
- Individual values defined several times are deleted. The list of individual values is sorted in ascending order after each change.
- Up to 30 individual values can be produced per registration.

Examples

- Current Storage Level of Reservoir 27
  - o SI [27.0]
- Satisfaction percentage of requirements of User 103.1
  - o 100 * AE [103.1] / E [103.1]

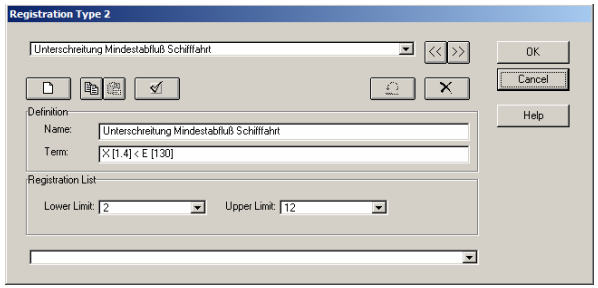
5.3.16. Registration Type 2

Variant

Menu Data Classes

Registration Type 2

Button



Attributes

Name

- Maximum of 60 alpha numeric characters

Logical term

- The logical term defines the registered event via utilisation of available program variables and functions, **comparative operators**, parenthesis, as well as arithmetic functions in accordance with the used FORTRAN-compiler, respectively.

- The reference to model object attributes (Balance Profile discharge, Reservoir Storage Level, User return flow etc.) takes place by using the corresponding number in brackets, e. g. X[1.2], E[4.11] or SI[3.0].
- As **comparative operators** the following can be used `.GT.`, `.LT.`, `.GE.`, `.LE.`, `.EQ.`, `.NE.` or >, <, >=, <=, ==, /=.
- If number variables are compared in a logical term, the internal program variable units of measurement are to be considered, e. g. current Reservoir Storage Level in hm^3, discharge, withdrawal, return flow or Reservoir release in hm^3/Mon, respectively.
- A term may be up to 255 characters long.

Lower and upper limits of the registration list

- Select duration of event, starting in the months January, February ... December (1, 2, ... 12)
- Lower Limit LL < Upper Limit UL

Examples

- The event that the discharge rate at Balance Profile 1.7 falls below the value 1.3 m^3/s is to be registered. The logical term then has to be:

  o X [1.7] < 3.42

  since variable X is measured in hm^3/Month and 1.3 m^3/s * 2.628 * 10^6 s = 3.42 hm^3/Month.

- The frequency of current Reservoir Storage Level of Reservoir 1 being between [3.5 hm^3 .. 4.0 hm^3] is to be registered.

  o (3.5 <= SI [1]) .AND. (SI [1] <= 4.0)

- The meaning of values in the registration table:

  o The registration term is likely to be TRUE one after the other n months with x %, beginning in month m. In that respect any included shorter sections are not contained within the event duration registration of n months.

Abscissa	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Duration= 1 Mon	2.2	1.2	**2.6**	3.4	4.6	2.8	3.6	2.0	3.0	1.0
Duration = 2 Mon	1.0	0.0	1.4	2.6	2.8	2.8	5.2	2.2	1.2	0.6
Duration = 3 Mon	0.0	0.4	0.2	3.0	0.4	2.2	5.8	**1.4**	0.6	0.0
Duration = 4 Mon	0.0	0.0	0.4	0.6	2.8	4.0	5.8	1.8	0.0	0.0
Duration = 5 Mon	0.0	0.2	0.4	0.6	6.6	2.0	2.4	0.0	0.0	0.0
Duration = 6 Mon	0.0	0.2	0.4	2.8	4.4	2.4	1.0	0.0	0.0	0.0
Duration = 7 Mon	0.0	0.4	1.4	3.0	3.2	0.8	0.2	0.0	0.0	0.0

Abscissa	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Duration = 8 Mon	0.0	0.2	0.4	3.0	0.8	0.0	0.2	0.0	0.0	0.0
Duration = 9 Mon	0.0	0.0	1.4	0.0	0.4	0.0	0.0	0.0	0.0	0.0
Duration = 10 Mon	0.0	0.6	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Duration = 11 Mon	0.6	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0
Duration>= 12 Mon	0.0	0.0	0.0	**0.2**	0.0	0.0	0.0	0.0	0.0	0.0

In 2.6 % of all simulated months March has fulfilled the formulated requirement of the registration term (x = 2.6, m = 3, n = 1).

In 1.4 % of all simulated months, August, September and October have fulfilled the formulated requirement of the registration term (x = 1.4, m = 8, n = 3).

In 0.2 % of all simulated years, each beginning in April, the formulated requirement of the registration term has been fulfilled (x = 0.2, m = 4, n = 12).

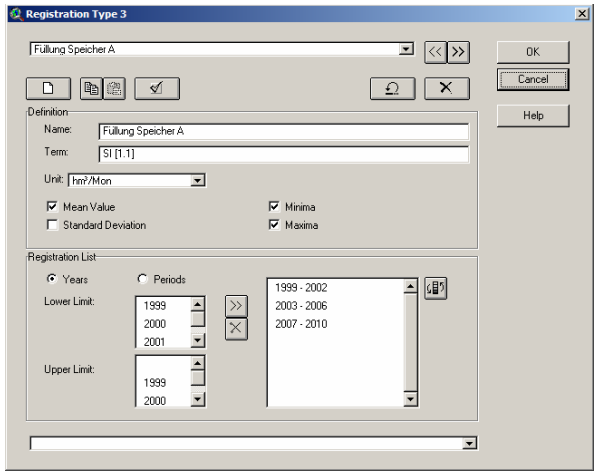
5.3.17. Registration Type 3

Variant

Menu Data Classes

Registration Type 3

Button



Attributes

Name

- Maximum of 60 alpha numeric characters

Arithmetic term

- The arithmetic term defines the value to be registered by utilisation of available program variables and functions, parenthesis, as well as mathematical and numeric functions in accordance with the used FORTRAN-compiler, respectively. The reference to model object attributes (Balance Profile Discharge, Reservoir Storage Level, User Return Flow etc.) takes place by using the corresponding number in brackets, e. g. X[1.2], E[4.11] or SI[3.0].
- A term may be up to 255 characters long.
- If the registered value is not within the interval -9999.99 ... 99999.99, a warning is displayed.

Select unit of measurement

- Standard units m³/s, hm³/mon., 1000 m³/d, l/s, hm³ or %
- Further available units

Select tables to be issued

- The table mean value cannot be excluded.
- The values in the table bear the following meaning for each section of the registration list:

Table	Name in the result file	Column	Meaning
Mean value	3A	Jan – Dec	Monthly mean value
		Year	Yearly mean value
		MNQmon	Smallest monthly mean value MNQmon is identified by calculating the smallest monthly value of each simulated year. From the set of calculated smallest monthly values (for instance 1000 values if 1000 years are simulated) the mean is derived.
Standard deviations	3B	Jan – Dec	Standard deviations of monthly mean values (see also 3A)

Table	Name in the result file	Column	Meaning
		Year	Standard deviations of yearly mean values (see also 3A)
Minimum	3C	Jan – Dec	Smallest values of months
		Year	Smallest value of yearly mean values
Maximum	3D	Jan – Dec	Highest values of months
		Year	Highest value of yearly mean values

Registration List

- The registration list is valid for all variants of registration type 3.
- Individual years
  - Activate the control box „Year“
  - Highlight the desired year from the list „Lower Limit“ (several years can be selected by holding down the SHIFT key)
  - By pressing the button selected values in the registration list are adopted
- Fractions of time (years)
  - Activate the control box „Year“
  - Mark the „Lower Limit“ and „Upper Limit“
  - Adoption by pressing the button
- Fractions of time (periods)
  - Activate the control box „Period“
  - Mark the „Lower Limit“ and „Upper Limit““
  - After pressing the button the relevant years are displayed in the registration list
- Individual years and fractions of time across several years can be combined with each other in the registration list. Via the button the order of grading is set: individual years may be stored before or after the given time period.
- By pressing the button selected values in the registration list are deleted.

5.3.18. Registration Terms: System Variables and Functions

Object	Variable	Meaning	Art
	ANZR	Number of Realisations	Z, *)
	NREL	Serial number of current Realisation (1...ANZR)	Z, *)
	ANZP	Number of Periods	Z, *)
	NPER	Serial number of current Period (1...ANZP)	Z, *)
	LP	Period Length in years	Z, *)
	JAHR	Simulation year within a Period (1...LP)	Z, *)
	MON	Current Month (1...12)	Z, *)
C-Field	C (i)	Period-related field of variables of type REAL(4)	D, (Z)
	CC (i)	Period-independent field of variables of type REAL(4)	(Z)
Balance Profile	X [Bp]	Discharge	Z
	XS [Bp]	Protected Discharge	Z
Simulation Sub Area	Q [SSA]	Natural Yield	Z
Simulated Series	Q [SSA]	Model-dependent	Z
User	E [N]	User Demand (planned value)	D
	R [N]	Return Flow (planned value)	D
	AE [N]	Actual Withdrawal	D

Object	Variable	Meaning	Art
Reservoir	SK [S]	Reservoir Capacity	D
	NG [S]	Active Reservoir Capacity	D
	GR [S]	Number of Reservoir slices in case of associated operation	D
	B4 [S]	Reserved Variable	D
	SIA [S]	Reservoir Storage Level at the start of the month	Z
	SI [S]	Reservoir Storage Level during or after the calculation in the time-step of a month	Z
Release-Element	G [Ab]	Target Storage Level	D
	BETA [Ab]	Coefficient for calculation of Target Storage Level (G) depending on SIA	D

i Index of a C-field-or CC-field-element
Bp Number of a Balance Profile
SSA Number of a **Simulation Sub Area**
N Number of a User
S Number of a Reservoir
Ab Number of a Release-element
D Variable of Definition
Z Variable of State
(Z) Variable of State, value allocated in DYN-element
*) Utilisation appropriate with registration terms in type 1 and type 2

5.3.19. Activate / Deactivate Registrations

Defining multiple of registrations for a variant is possible. Especially in the case of several revisers for a model, each one with different foci on results, by selected switching in or off of registrations the display of results can be optimized. Another example of appropriate

utilisation is with changes in the model (or the creation of a new model) of larger extent, where first registrations can at least give rough estimates for the plausibility of the model. Other registrations do not need to be deleted in this case.

Only activated registrations are considered in the simulation: if all registrations are deactivated, the calculation cannot be started.

Variant

Menu Data Classes

Activate Registrations

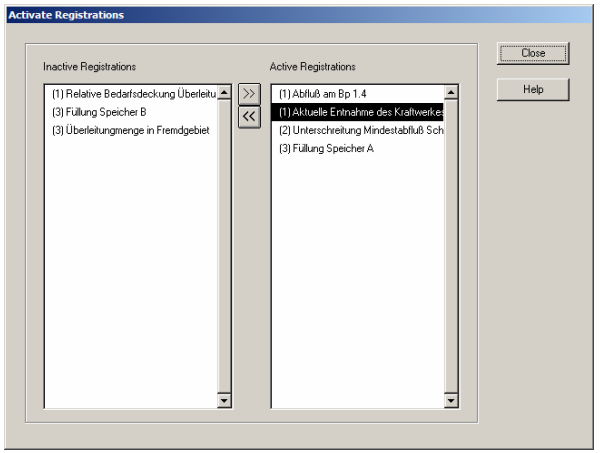
Dialogue

Registration Type 1

Registration Type 2

Registration Type 3

Button



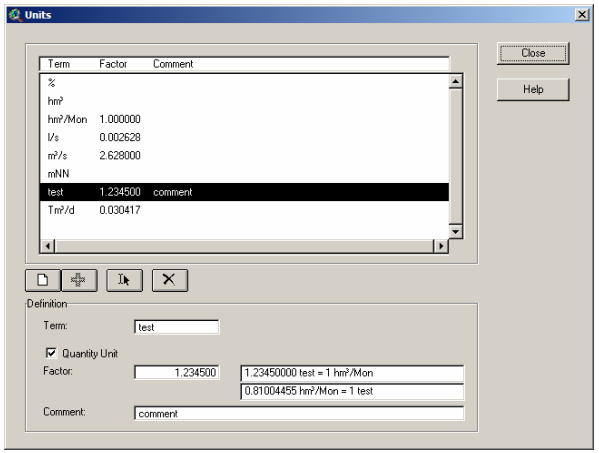
5.3.20. Units

Individual units can be set for data classes as Simulation Sub Area and Users, as well as for registrations type 1 and type 3, respectively. This is particularly useful for the utilisation of input data for the model and of results concerning non quantity based modelling.

Variant

Menu Extensions

Units



Attributes

- Name (max. 5 characters)
- A conversion factor, in hm³/Mon, has to be entered if quantities are examined.
- Units for quantities are available for the definition of Simulation Sub Area (river basin with natural yield) and Users, respectively. Access to these units is also possible by the conversion function.
- All units can be applied for the establishment of registrations.
- For units not concerning quantities no conversion to run-time is carried out.
- Writing a comment for a unit is optional.

Standard units hm³/Mon, l/s, m³/s, km³/d, hm³, % cannot be edited or deleted.

New

- Enables the new definition of a unit

Add

- Adds the unit edited to the list of available units.
- A unit is only added, if no unit of the same name already exists.

Editing

- Overwrites the unit highlighted in the list with data entered in the input window
- Changing a units name is only possible, if the new name is not in use already.

Delete

- Deletes the unit highlighted in the list.

Examples

- Long, simulated series of global radiation kJ/m²/d
- Concentration of a substance mg/l
- Water table under surface m

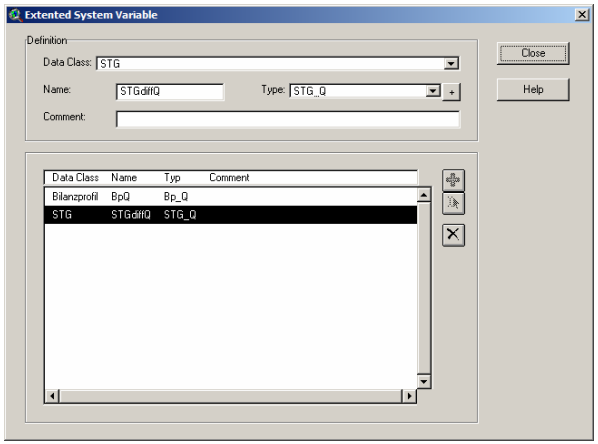
5.3.21. System Variable

Access to WBalMo standard data of objects concerning the data classes **Balance Profile** (X, XS), **Simulation Sub Area** (Q), **User** (E, AE, R), **Reservoir** (SK, NG, GR, SI, SIA, B4) and **Release-element** (G, BETA) within a variant takes place in DYN-elements and registrations by code numbers. After an extension of available data of the selected data classes has been made, they then become accessable via the normal code numbers. The objective, beside an efficient implementation of model specific algorithms in DYN-elements, is the legibility of registration terms in the result file.

Variant

Menu Extensions

System Variable



Attributes

Data Classes

- Selection of User class to be extended (**Balance Profile**, **Simulation Sub Area**, **User**, **Reservoir**, **Release-element**)

Name

- The name of the variable has to conform with FORTRAN-conventions.
  - Names may consist of up to 31 alpha numeric characters. The first character has to be a letter.
- The name may not be otherwise used.
  - The set variable is globally available in all DYN-elements. It must be ensured, that neither other global, including standard-system-variables, nor local variables with the same name are used. The same is true for names of functions.

Type

- Standard data types: REAL(4), REAL(8), INTEGER(1), INTEGER(2), INTEGER(4), LOGICAL(1)
- User defined data types
  - Access to user defined data types (structure components), set by utilisation of predefined data types and globally available in modules, is permitted.

- After pressing the button + and entering the desired type name, its components can be accessed in DYN-elements and registration terms.

Comment

Examining Data

The examination of code numbers for extended system variables takes place in the same way as with WBalMo standard data.

Utilisation

Simple variable

- Definition of variable
  - Data class: Reservoir
  - Name of variable: Area
  - Data type: REAL(4)
- Utilisation in DYN-element (condition: Reservoir 1.7 exists)
  - AREA[1.7] = exampleFunction (SI[1.7])

Assembled variable

- Type definition in a module of the same variant

```
TYPE SB
  REAL(4)    :: maximum_reservoir_capacity
  INTEGER(1) :: soil_type
   REAL(4)     ::  groundwater_table  !  above
sea level
END TYPE SB
```

- Definition of variables
  - Data class: User
  - Name of variable: storage_capacity
  - Data type: SB
- Utilisation in a registration term type 2 (condition: User 10.25 exists, calculation of data to be registered took place in a DYN-element)
  - Storage_capacity[10.25]%groundwater_table<61.2

Examples

- Extended quantity model: surface area of Reservoirs for calculation of evaporation losses
- Hydraulic model: extension of data for Balance Profiles by bed level and limiting maximum possible discharge
- Model for groundwater balance calculations of large areas: extension of data for all Users by data for groundwater table under surface and / or a complex structure "storage-capacity"
- Water quality model: eutrophication of lakes and reservoirs

5.3.22. Modules / Parameters

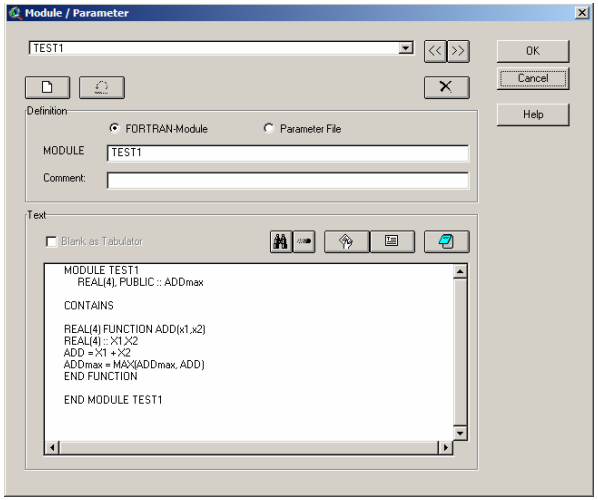
Within a dialogue the definition of FORTRAN-modules, as well as parameter files, which are used for instance in DYN-elements, is possible.

Variant

Menu Extensions

Modules / Parameter

The buttons for editing texts are identical to those in DYN-elements.



Modules

FORTRAN-modules in WBalMo serve to define global variables, functions and generally available sub programs, as well as supply user defined data types. All modules contained in a variant are automatically associated with DYN-elements and registrations of this variant.

Attributes of a module

MODULES

- The name of the module has to conform with FORTRAN-conventions.
  - Names may consist of up to 31 alpha numeric characters. The first character has to be a letter.
- The name may not conflict with other program units.

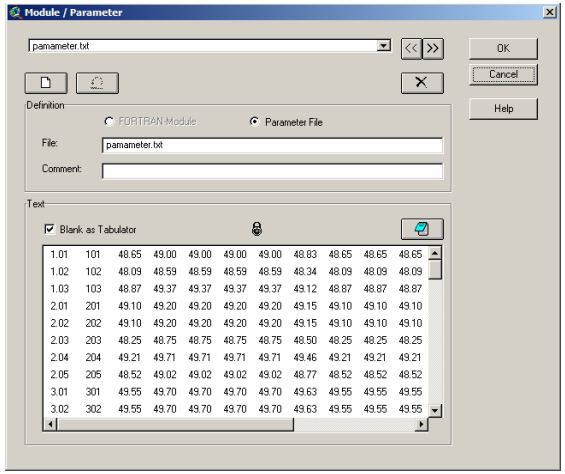
Comment

Text

- The text contains a complete programmed module including "MODULE"- and "END MODULE"-allocation.
- The name used for the module is to be identical to the name chosen in MODULE.
- Access to WBalMo system variables in module-functions is not permitted.

Parameter file

If parameter files are used in DYN-elements, the portability of the model becomes limited. This is due to longer path names wich have to be updated when changes are made. For easier handling the parameter file can be addressed in the model data of the variant directly. The name of the parameter file is the physical file name, that means this name (without indication of path) is to be used in the reading routine (in DYN-element or in a module). During initialisation of the simulation this file is exported to the working directory %WBalMo2%\tmp.



Attributes of a Parameter File

File name

- If the **file name** contains a file path, the existence of this directory is to be ensured.

Comment

Text

- If the view "blank as tabulator" is chosen, editing is only possible with anexternal editor.

5.3.23. External Functions (DLL)

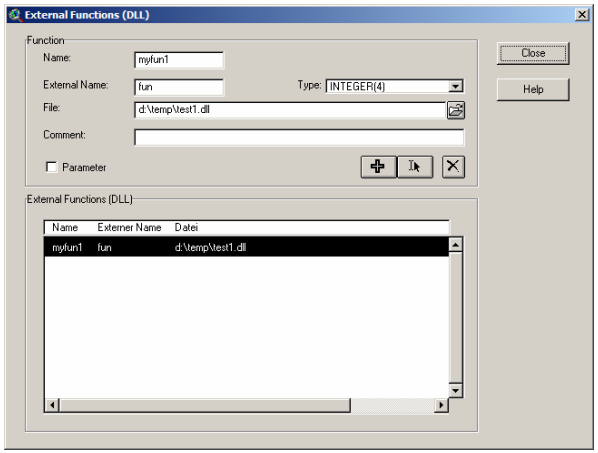
Beside algorithms described in DYN-elements and modules in FORTRAN-notation, also functions already compiled (binary) from

Dynamic Link Libraries (DLL) can be used in WBalMo. Basis is the utilisation of standard interfaces for DLL-Functions and the definition of interfaces in WBalMo described below. Functions are acquainted then in DYN-elements and registration terms, and can be used in those.

Variant

Menu Extensions

External Functions (DLL)



Attributes

Name

- Name, which is to be used for the function in WBalMo

External name

- Name of the function exported from DLL

Type

- Data type of the return value of the function: REAL(4), REAL(8), INTEGER(1), INTEGER(2), INTEGER(4), LOGICAL(1), SUBROUTINE
- If the function to be implemented contains a return value like void, the type SUBROUTINE is to be used.

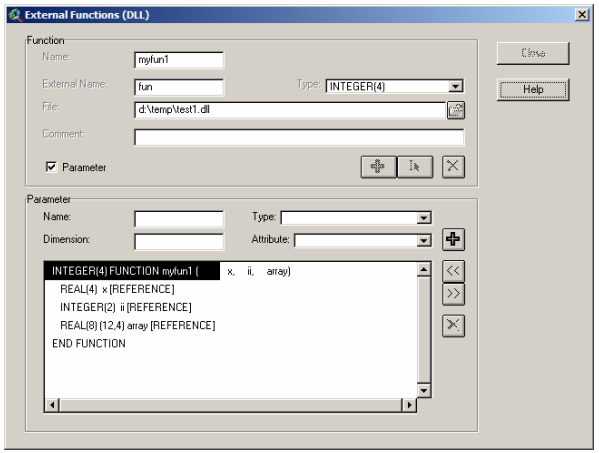
File

- By the file dialogue file name and path of the DLL are established.
- If the file cannot be found in the designated directory by WBalMo, a message is displayed .

Comment

All new edits or changes are to be confirmed by the buttons or .

Formal Parameter



Parameter

- **Name**
  - Name convention according to FORTRAN
  - Within the description of an interface names of variables may not be used more than once.
  - The name of formal parameters has no meaning within other program units.
- **Type**
  - Selection from: REAL(4), REAL(8), INTEGER(1), INTEGER(2), INTEGER(4), LOGICAL(1), CHARACTER(255)
- **Dimension**
  - If the entered variable is a field, its dimension is to be indicated according to logical arrangements in FORTRAN.
  - The indication of the key "DIMENSION" is not necessary, the field dimension is to be entered according to the above illustration, corresponding to the example "(12,8?)" is to be entered.
  - If fields, programmed in another language and using arrangements of fields other than FORTRAN (e. g. C, PASCAL), are used in DLL-Functions, corresponding conversions are to be carried out.
- **Attribute**
  - Singular variables can be transferred by REFERENCE or by VALUE, fields exclusively by REFERENCE.

Add

- Highlight the function's name
- Entry of the parameter's properties
- Add (at the end of the list) with

Change properties

- Highlighting the parameter to be changed in the declaration
- Changing properties

Change order

- Highlight the parameter to be changed in the head of the function
- Shift to the left / right with or .

Delete

- Highligh the parameter to be deleted in the head of the function
- Delete with

Storing changes to parameters is carried out automatically. To reach the editing level of the general definition of the function, the button "Parameter" is to be deactivated.

- Before the start of a simulation WBalMo examines, if the DLL-files are at the indicated position, as well as the availability of the function exported by the DLL. If necessary an error message is displayed and the calculation is interrupted.

5.4. Calculation of Variants

5.4.1. Examining Data

Variant

Menu Variant Calculation

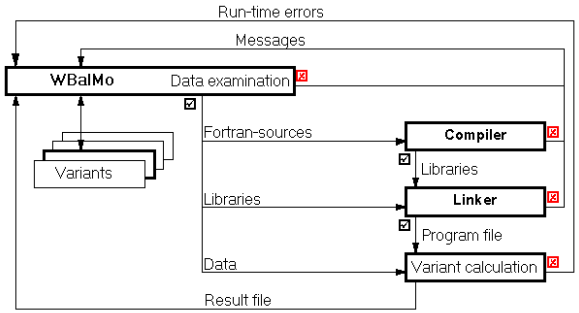
Data Examination

- All data of the variant are checked in order to guarantee the initialisation of the variant calculation without errors and to minimise potential run-time errors.
- Examination of program variables used in DYN-elements and registrations is an essential part of this module. If code numbers, used in DYN-texts and registration terms, are no longer available after being correctly stored, either due to renaming or deleting model elements themselves, an error message is displayed.
- The following is also examined:
  - the existence of at least one Running Water, Balance Profile, Simulation Sub Areas, User, and registration (type 1, 2 or 3), respectively
  - whether the initialisation of the C-field took place
  - the availability of files for the natural yield for all Simulation Sub Areas within the indicated directories.
- Any inconsistency is displayed in a message.
- Data examination is carried out automatically before starting the variant calculation.
- If an initialisation took place by a user, all data series for Simulation Sub Areas are examined for correct content with regard to WBalMo. Additionally: each line contains 12 numbers with decimal separator ".", separation of columns by TAB, blank or ",". The resulting

number of individual years for a possible simulation (= corresponding number of correct lines of all files) is displayed in a message.

5.4.2. Start of Calculation

Each variant calculation takes place according to the sequence of events represented.



☒ Any errors or issued warnings found during data examination in compiler / linker are saved and displayed in a message. Further running of the whole function is terminated.

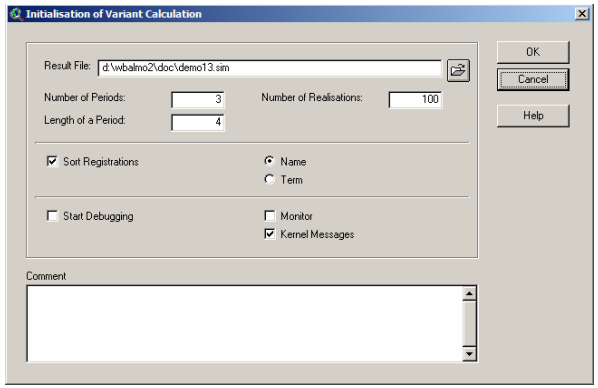
☑ Otherwise, steps up to and including the generation of the result file is carried out as a result of the variant calculation. If requested the result file is displayed following the variant calculation.

The data examination module, messages and result file can be viewed individually.

Variant

Menu — Variant Calculation Initialisation / Start

Button



Result File

- Enter path and file name
  - o Registration tables (registration type 1, registration type 2, registration type 3) are stored in the result file.
- All files described via DYN-elements are saved in the given directory. Files with file names but no path are located in the directory `%WBalMo2%\TMP`.

Information about the number of periods and the length of a period

Length of Variant Calculation

- Depending on the simulation model used as a basis for a variant (properties of the variant **and** shortest data Series for Simulation Sub Areas / simulated series) a simulation is performed
  - with a number of periods ANZP > 1 and a number of **realisations ANZR**
    - 1 ≤ ANZR ≤ length of data series in ANZP•LP•ANZR
  - or with ANZP = 1 and a **number of individual years YEAR**
    - 1 ?YEAR?length of data series in years.

Sorting registrations

- Registration tables are displayed in the result file in the same order as they are stored physically in the dBase-file.
- Before the start of the calculation those data sets can be sorted in alpha numerical ascending order by **name** or **registration term** alternatively.
  - If the name contains a number (point as decimal separator) at the beginning that is separated by a blank, sorting takes place according to this number, subsequently according to the content of the remaining character string.

Start Debugging

- If this option is activated, the files that the simulation is based on are exported into an indicated directory (standard: `%WBalMo2%\TMP`) and the development platform Visual FORTRAN is started.
- This choice is only available after the path has been installed in the general program preferences.

Monitor

- Activation of display of simulated values during the calculation starts at the beginning of the second month.

Messages GRM-Kernel

See also chapter 5.4.5 Testing of Permissible Settings by GRM-.

Comment

- The **comment** is copied from the properties of the variant. It is possible to modify it for a variant calculation temporarily. In the result file the first **five lines of the comment** are saved.

5.4.3. Messages

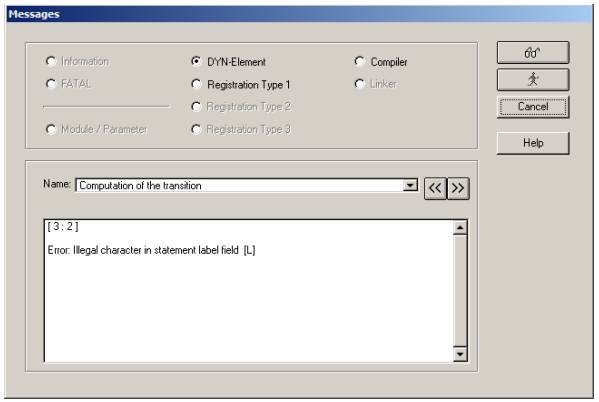
Error messages and warnings are displayed if

- data errors have been found by data examination or
- e. g., syntax errors (FORTRAN) have been found by compiler / linker in DYN-texts or registration terms.

Variant

Menu Variant Calculation

Messages



Information

- Displayed is the maximum number of individual years to be simulated, for which in Simulation Sub Area series values in correct FORTRAN-notation are available. The position of errors is indicated. An examination of data series is carried out only by „Data Examination“.

FATAL

- Missing data or fundamental errors, e. g., no model structure (Running Waters and Balance Profiles), Simulation Sub Areas data incomplete or not up to date.

Module / Parameter

Errors detected by the compiler in a module definition are displayed.

DYN-Element

- Missing references of code numbers used in DYN-texts of the variant.
- After selecting a DYN-element from the list of names of all incorrect DYN-elements or by scrolling with << >> the error messages or warnings concerning the assigned DYN-element are displayed.
- By clicking the OK button the selected DYN-element is opened (for correction).

Registration type 1, registration type 2, registration type 3

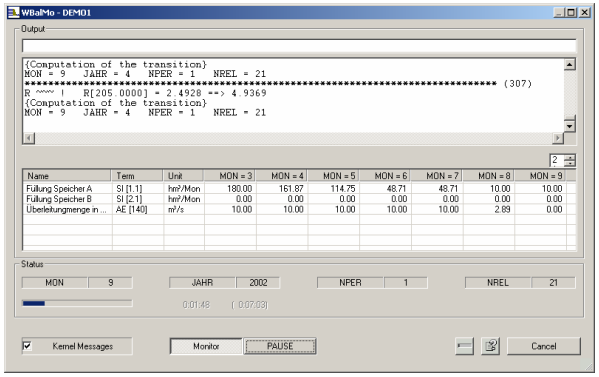
- Missing references to code numbers used in the registration term.
- Selecting and opening an incorrect registration takes place just as with DYN-elements.

Compiler, Linker

- Since a series of messages cannot be assigned to DYN-texts or registration terms, the whole protocol file of the compiler or linker is displayed.
- Functions / sub programs used in DYN-elements or registrations, which have neither been defined in the variants DYN-texts nor in WBalMo-Kernel, are found by the linker.

- The program file of the variant calculation is performed. Existing compiler / linker warnings are ignored in this process.
- Run-time errors may occur.

5.4.4. Calculation



During the simulation the following information is displayed:

- Status (time-step, relative)
  - Month, year, period, realisation
  - Passed and remaining (estimated) run-time
- Output Line
  - Messages from DYN-elements
  - Quick output text, overwritten with each new instruction.
- Large Output Window
  - Messages from GRM-Kernel
  - Messages from DYN-elements
  - If texts are read out during the calculation, the program dialogue is to be closed by the user.

Messages from GRM-Kernel

- The button may be deactivated, if an initialisation of the simulation took place with this option.

Monitor

- If the monitor is activated, current simulated values as well as those of the preceding 6 month of all type 3 registrations are displayed.

- Calculation stops each month for approx. 2 seconds.
- At the beginning of the monitor-mode PAUSE is triggered for program synchronisation.
- A control of the monitor is also possible with DYN-elements.

PAUSE

- By setting the button PAUSE the calculation is stopped, by deactivation the calculation is continued.
- PAUSE can also be triggered by DYN-elements.

Priority

- The **priority** of the simulation program is "low" by default, to enable the utilisation of the computer for other applications, e. g., word processing, especially during long run-times. By changing the button (**priority** "normal") the simulation can be accelerated. Other active programs, however, are negatively influenced with regard to their performance then.

Help

5.4.5. Testing of Permissible Settings by GRM-Kernel

A number of tests are carried out during entry of the data of elements for data classes via corresponding dialogues. By setting system variables in DYN-elements rules regarding run-time can be ignored. A number of plausibility checks enable the user to locate and correct inadvertent settings. The kind of error, the time-step of its appearance (month, year, period, realisation), and the name of the DYN-element responsible are displayed.

- It should be noted that the examination does not check the contents of the algorithms implemented in DYN-elements.
- Since the checks require some time, they should be excluded for "established" models.

Error code		Meaning	Reference/Information
101	X < 0	A negative discharge X was calculated on a Balance Profile.	
102	X < 0, CHXX	By changing discharges on a track with CHXX on several Balance Profiles negative	

Error code		Meaning	Reference/Information
		discharges X were calculated.	
103	< XS	The protected discharge XS was reduced.	
104	X < XS	The discharge X was reduced downstream of the protected discharge XS.	
301	E < 0	The demand E is negative.	
302	R < 0	The return flow R is negative.	
303	E < R	The demand E is lower than the return flow R.	Permitted: E = 0 and R > 0.
304	E > 0	For a User of type CR a demand E was set.	E is automatically corrected to 0.
305	R > 0	For a User of type Qmin a return flow R was set.	R is automatically corrected to 0.
306	E~~~	The yearly value of E was overwritten.	In case of a conditional setting of E this condition is not valid. E has the value of the preceding month then, the accurate criteria does not need to be valid. The (yearly) value entered in the dialogues mask is lost. When using an annual cycle it is ensured that the value set in the DYN-element is used in the current month, no value of this list entered in the dialogue is overwritten either.
307	R~~~	The yearly value of R was overwritten	see Error code 306
1101	-9999.99 < R3 < 99999.99	The value of a registration term is outside the permitted interval	Changing the arithmetic term

Error code		Meaning	Reference/Information
1002	R3B => ?	During the calculation of the standard deviation an error occurred.	This error may arise in the case of (nearly) all data of the population having the same value. The examination of tables 3A (mean value), 3C (minimum) and 3D (maximum) is recommended. If necessary the output of 3B should be excluded. This message cannot be deactivated.

5.4.6. Result File

After regular termination of the variant calculation the associated result file (registration type 1, type 2, type 3) is displayed if desired.

Independent of the active variant, result files (*.sim-files), which were produced by previous variant calculations of this or other WBalMo-variants, can be opened.

Project

Menu Variant

Result File

Variant

Menu Variant Calculation

Result File

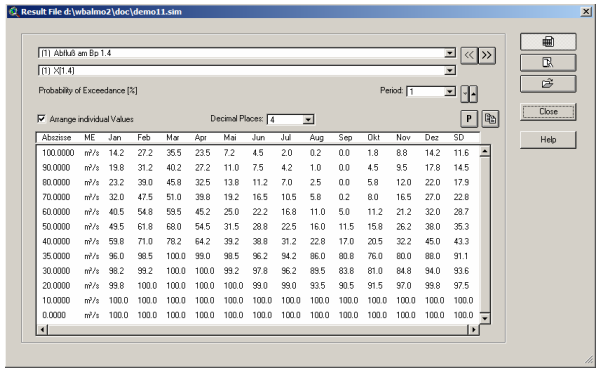
Dialogue Result File

Button

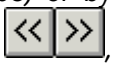
View of Registration Tables

- Button

Only one registration table can be displayed at a time.



Selecting a registration

- The desired registration is selected from the list of names, the list of registration terms (of all registrations, independent of type) or by scrolling with the buttons  , alternatively. The type of the registration is displayed in brackets in front of the name and the registration term.
- The registration table of the chosen period is displayed.

Selecting a period (only type 1 and type 2)

- This display and the possible selection are not shown, if the current displayed result file is the result of a variant calculation with only one period.
- For the chosen registration the corresponding registration table is displayed after selecting a period from the list of period numbers or by scrolling .

Arrange individual values (only type 1)

- Individual values are always stored according to the regular registration tables. Individual values are arranged (visually) in the regular table by activating the control box.

Selecting a table (only type 3)

- Each registration type 3 may contain up to four tables: mean value, standard deviation, minimum and maximum. By selecting a table type from the list or by the corresponding table is displayed.
- **Each table** contains the values for all determined individual years and fractions of time.

Decimal places

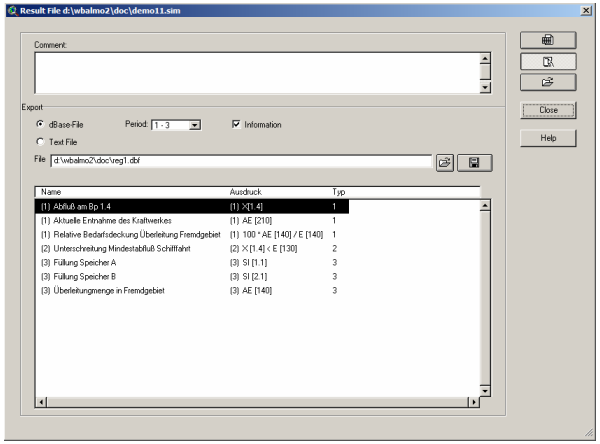
- The value of the abscissa (registrations type 1) or of registered results of type 3 can be displayed with 0 … 6 decimal places.

Copy Table

- The table displayed is copied into the Windows clipboard. Subsequently it can be inserted for instance into a spreadsheet calculation. Tabs are used as separators of data in lines.
- The displayed decimal point is replaced by the decimal separator set in the general program options.

Exporting Registration Tables

- Button



Details of the loaded WBalMo result file

- The name of the **file** and the **comment** are displayed.

Selecting the registration table to be exported

- All registrations contained in the `*.sim` file are displayed as lists including name, term, and type, respectively.
- Registration tables chosen from the list can be stored as **dBase-files** or as **text-files**. The defining of directory and name for the output file (file) takes place by the button .
- Only *one* registration table can be exported in a dBase-file. However, more than one registration may be written in a text-file. It is possible to select more than one registration from the list of registrations by using the mouse whilst holding down the SHIFT key.

Period

- Only the registration table of the chosen period is exported. All tables are copied, if „1 – NPER“ is chosen.

Information

- The following information is stored: path and name of source file (`*.sim`), variants comment, registration name as well as registration term.
- Export as dBase: text is stored in an ASCII-file of the same name with the file extension `*.inf`.
- Export as text: Information concerning variants (`*.sim`-file, comments) are placed at the top of the file. Registration details are always displayed before the corresponding tables.

- Export takes place according to the above established options.

Hint

In Addition to the export function described, the whole result file (*.sim -file) can be loaded into an external editor.

5.5. Extras

5.5.1. Ranking List

The ranking list is generated as dBase-file. Details concerning all elements with ranks of the current variant are stored in this table. It contains the following columns:

- **Type** N = User, AEND = AEND-element, AB = Release-element, DYN = DYN-element
- Code number
- Name
- **E-profile, R-profile** withdrawal profile or User return flow profile
- Reservoir code number for assignment of Release- or AEND-elements
- **Z** Rank

  Z_P*p* *p* Number of period

  Z_P*p*_**M***m* *p* Number of period, *m* month

  Similar to the ranking list scale

The dBase-file is (physically) generated in the following sequence: User, Reservoir AEND-elements, Release-elements, DYN-elements. Sorting (e. g., in ascending order according to ranks) then takes place either in WBalMo (similar to view of a table) or externally, e. g., in a spreadsheet calculation.

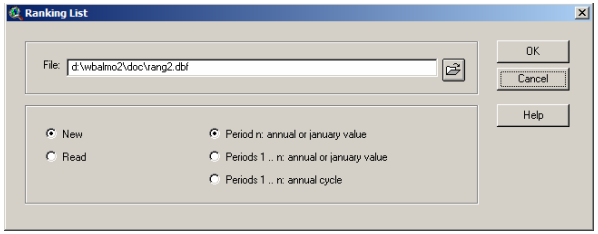
Variant

Menu Extras

Ranking List

Button

Generate Ranking List / Read dBase-Files



Specifying a file

- By the file name is set.
- By activating the control box **New** a ranking list is generated and displayed afterwards. The default directory is established in WBalMo options (**file**).
- After activating the option **Reading** the selected dBase-file is displayed.

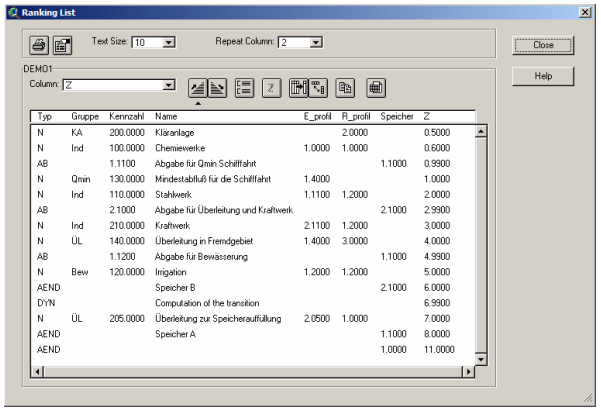
Ranking list scale

Ranks of Users, Release-elements, Reservoir AEND-elements and DYN-elements, respectively,

may both vary within a year, as well as over periods (but not with DYN-elements). Thus 12*ANZP different variant ranking lists can occur. Three categories are available to generate ranking lists:

- a ranking list, which contains the ranks of yearly values or (with annual cycle) January values of the **last period**,
- **ANZP** ranking lists, which contain the ranks of yearly values or (with annual cycle) January values of **all periods**,
- **12 ANZP** ranking list, which contains **all ranks of monthly values** of **all periods**.

View of a Table


Ranking List
Text Size: 10
Repeat Column: 2
Close
Help
DEMO1
Column: Z
Typ Gruppe Kennzahl Name E_profil R_profil Speicher Z
N KA 200.0000 Kläranlage 2.0000 0.5000
N Ind 100.0000 Chemiewerke 1.0000 1.0000 0.6000
AB 1.1100 Abgabe für Qmin Schifffahrt 1.1000 0.9900
N Qmin 130.0000 Mindestabfluß für die Schifffahrt 1.4000 1.0000
N Ind 110.0000 Stahlwerk 1.1100 1.2000 2.0000
AB 2.1000 Abgabe für Überleitung und Kraftwerk 2.1000 2.9900
N Ind 210.0000 Kraftwerk 2.1100 1.2000 3.0000
N ÜL 140.0000 Überleitung in Fremdgebiet 1.4000 3.0000 4.0000
AB 1.1200 Abgabe für Bewässerung 1.1000 4.9900
N Bew 120.0000 Irrigation 1.2000 1.2000 5.0000
AEND Speicher B 2.1000 6.0000
DYN Computation of the transition 6.9900
N ÜL 205.0000 Überleitung zur Speicherauffüllung 2.0500 1.0000 7.0000
AEND Speicher A 1.1000 8.0000
AEND 1.0000 11.0000

Set active column

Selection of the active column takes place either by selecting a value from the list of column names or by clicking the desired column in the table (not at the head of the table).

The table is sorted in **ascending** order according to the values in the active column.

The table is sorted in **descending** order according to the values in the active column.

The active column is **searched for values existing repeatedly**. These are highlighted and their number is displayed.

The **table view** is switched with this button:

- The columns' width may vary and is dependent on the contained values. Possibly not all columns are visible at the same time.

  Or

- all columns have the same width and are displayed at the same time.

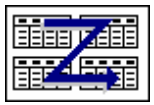
Printing a Table

The A4 paper portrait and A4 paper horizontal formats are supported for the printout.

Text Size

- The text size for the table head, contents and foot notes (file name, current page number) can be selected between 8 .. 12 points.

Repeating Columns



- If the table is wider than the printing medium, any surplus columns are printed on a new page. In addition up to 2 table columns can be produced on each page as repetition columns.
- The column width is adapted to its contents (per printed page) and to the chosen text size.

Setting up a Printer

- By clicking the button the Windows dialogue for selecting and installing a printer is activated.

Printing

- After pressing the button the table is processed for printing. The **active column**, in **ascending** or **descending sorting direction**, is then considered.
- Each page is printed as a separate printing task.

5.5.2. Report

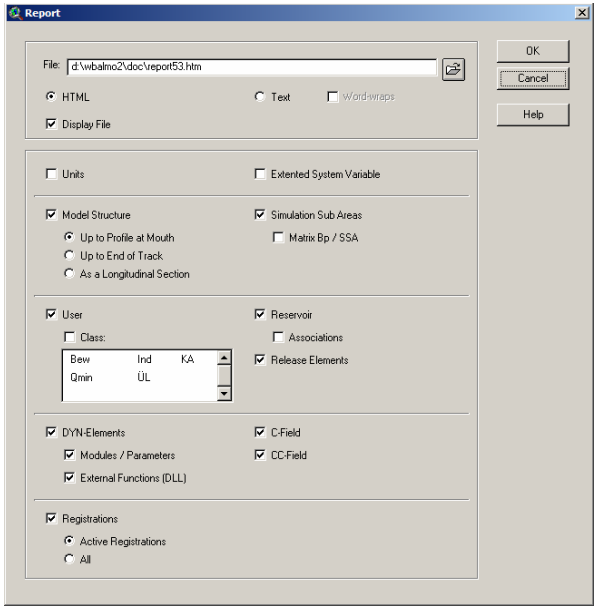
The report, containing the data of a variant, may be created as an HTML-file or as an ASCII-file. The advantage of the HTML-report is the availability of references to data of different data classes as links, thus the navigation within the report is possible.

Variant

Menu Extras

Report

Button



File names and properties

- Selecting a file type
- Establishing path and file names
  - The default directory is established in WBalMo options (chapter 2.6 Option).
- Word-wraps can be predefined for ASCII-files.
  - Values of lists (annual values, individual values of registrations type 1, ...) are issued as a block.
  - The editing necessary for a printout of the ASCII-file thus is minimised.
- If the report-file is to be displayed immediately, the control box **Display File** is to be activated.

Limiting to relevant data classes

- **Units**
  - Additionally to variant-specific all standard units are issued.
- **Extended system variable**
- The **model structure** as lists of all defined Balance Profiles and Reservoirs. The elements' code numbers and names are issued. Reservoirs are arranged into the structure. The order of issue starts with the lowest rank of the first Balance Profile of all segments.
  - The list contains Balance Profiles / Reservoirs of the tracks up to their mouth
  - The list contains all Balance Profiles / Reservoirs up to the fictive end Profile -999 of all sequential tracks
  - The list contains all Balance Profiles / Reservoirs up to the fictive end profile -999 of the whole river structure, the sorting of parts of the track is carried out as longitudinal section
- **Simulation Sub Areas**
  - If required a table containing the shares on the natural yield of all Balance Profiles

on Simulation Sub Areas can be generated.

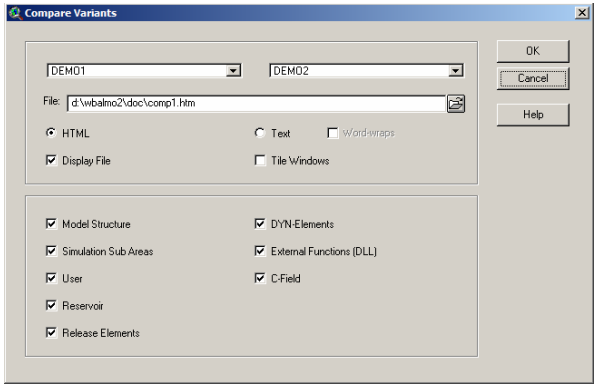
- The drawing up of a report of **User** data takes place with a filter or without a filter, alternatively. The character strings used as a selection criteria are entered into User data as **class**. A multiple selection from the list of available classes is possible by using the mouse whilst holding down the SHIFT key. The utilised filter is indicated in the report.
- **Reservoirs and Release-elements**
  - The classification of Reservoir definitions in predefined Associations is possible.
- **DYN-elements, modules/parameter, external functions (DLL)**
- **C-field, CC-field**
  - The element is issued, if the data are unequal to „0“ or a comment concerning the corresponding element is entered.
- **Registrations**
  - Deactivated registrations can also be displayed alternatively. This status is contained in the report.

5.5.3. Compare Variants

Variant

Menu Extras

Compare Variants



Specifying variants to be compared

- Only variants within a project can be compared.

Adjusting the output-file

- Selecting data type HTML- or text-file
  - The structures of the files correspond to a large extent to the structure of the reports.
- Enter path and file name
  - The default directory is established in WBalMo options (file).
- If the file is to be displayed immediately, the control box **Display File** must be activated.
  - Both of the variants to be compared can be displayed next to each other by selecting the control box **Tile Windows**.

Limiting to relevant data classes

- The comparison of data from non relevant data classes can be switched off.

The comparison of individual model elements is carried out in two steps:

- Existence of objects with equal primary attribute (code number, otherwise name) in both variants
- Comparison of all data assigned to the element. Each detected difference (also a blank in the text) is rated as a difference.

5.5.4. Editing the System Sketch

With this function visual corrections can be carried out. Modification of the model structure is not possible at the moment.

Variant

Menu Extras

Edit System Sketch

Geometry of the represented model elements can be changed in the system sketch depending on the relevant raster options (variant attributes).

Moving Objects

- Select a data class: **Balance Profile, SSA, User, Reservoir**
- A button „Edit System Sketch“ + *name of the data class* is inserted into the system sketch. It serves both information and the completion of the function itself.

Balance Profile

- Tool
- Select a point by clicking on it
- Move the point inside the relevant segment

Simulation Sub Area

- Tool
- Select a polygon by clicking on it
- Move a vertex point or
- Delete a vertex point:
  - o Positioning the cursor over the point to be deleted
  - o Pulldown „Delete SSA - vertex point“

User

- Tool
- Select a point by clicking on it
- Move the point

Reservoir

- Tool

- Select a point by clicking on it
- Move the point inside the relevant segment
- **Quit editing system sketch**

Variant

Menu Extras

Edit System Sketch

System Sketch

Button Edit System Sketch …“

Changes previously carried out are saved after confirmation.

Rotating of Reservoir Symbols

- When moving Balance Profiles and Reservoirs in the system sketch both neighbouring Running Water segments also are shifted.
- The Reservoir symbol is rotated by selecting the action „Align Reservoir“ in the list. A triangle side is displayed aligned vertically to the segment ‘flowing away’. The Reservoir symbol of the standard legend or a similar symbol is required for this process.

Hint

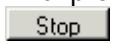
Balance profil, **Reservoir**: If another balance profile and/or another reservoeir is selected while editing the system sketch, unsaved changes made up to that point will be saved after confirmation.

5.5.5. Import of PC-GRM-Variants

This function serves the adoption of records which have been created with the PC-GRM or PC-GRYMDYN program.

The model structure (data class 1, lists of Balance Profiles) and the Simulation Sub Areas are not imported. Running Waters and Balance Profiles are to be entered into WBalMo before activating the import function.

Importing PC-GRM-variants takes place in two stages:

- First of all the PC-GRM-variant to be imported is selected. The data class files are read and integrated into the relevant WBalMo-variant. This process can be cancelled by pressing 

in the status bar.
- The second stage of importing model elements into WBalMo-variants is their final integration. All model elements are treated as newly defined, which means data examination of DYN-texts and registration

terms is carried out completely. However, instead of empty data the imported data are offered here. The integration of individual model elements has to be repeated, until all desired elements are component of the WBalMo-variant.

If required, data from different PC-GRM-variants can also be read in a WBalMo-variant.

Initialisation and Start

Variant

Menu Extras

Start PC-GRM Import

Selection takes place by establishing file names of a data class: 0, 3...9. All other data class files have to be stored in the same directory. At this stage Simulation Sub Area ASCII-files are not an integral part of a record. If the question, whether the selected files are PC-GRM data sets, is answered negative, the number of periods (for PC-GRMDYN) is to be entered afterwards. The function is cancelled if

- the record is incomplete,
- a PC-GRYMDYN variant is read as PC-GRM or
- the entered period number does not correspond to that of the PC-GRYMDYN variant.

Importing Data Class Elements

User, Reservoir, Release-element

An object is selected via its code number from the list of imported objects.

DYN-element, registration type 1, registration type 2

Selection takes place via name.

User

- Tool

The process is cancelled after a corresponding comment, if withdrawal and return flow profiles are not defined.

Reservoir

- Tool

Release-Element

Menu Data Classes

Release-Element

Button

The selection list only contains the Release-elements whose corresponding Reservoir is contained within the WBalMo-variant.

C-Field

Menu Data Classes

C-Field

Button C

The C-field is imported as a whole. If a C-field is already defined in the relevant variant, it is overwritten after confirmation.

DYN-Elements

Menu Data Classes

DYN-Element

Button D

Registration Type 1

Menu Data Classes

Registration Type 1

Button 1

Registration Type 2

Menu Data Classes

Registration Type 2

Button 2

Finish Importing

Menu Extras

Stop PC-GRM Import

Document Variant / View

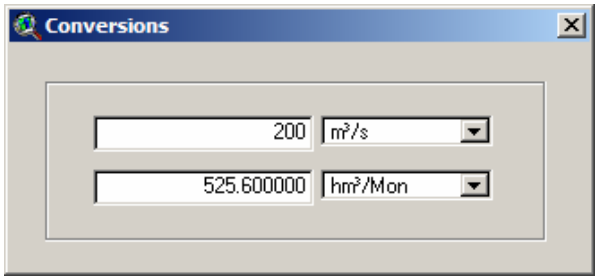
Stop PC-GRM Import

5.5.6. Conversions

Variant

Menu Extras

Conversions



The value entered is converted according to the selected units.

Beside Standard-Units

- m³/s
- km³/d
- hm³/Mon
- l/s

all quantity units of the variant are accessible (chapter 5.3.20 Units).

5.6. Graphic

5.6.1. Background Map

Load Background Map

Variant

Menu Graphic

Background Map

Themes can be added to the system sketch (ArcView Help „Adding a theme to a view“).

The theme is drawn in grey and the legend can be adapted as required (ArcView Help „Edit legend“).

Background maps are not only helpful for the drawing up of the system sketch, but also increase the information content of printouts of maps.

Hint

The application of this function is useful for drawing real geographical system sketches. The river network structure can be drawn up in WBalMo by simplified drawings, for instance by an Arc/Info coverage with the natural water network of the area of interest. Point geometry of Balance Profiles, Reservoirs and Users can also be entered into the system sketch on the basis of relevant map material with geographical reference.

Delete Background Map

Variant

Menu Graphic

Delete Background Map

The background map to be deleted is selected from the list of loaded background maps.

5.6.2. Labelling

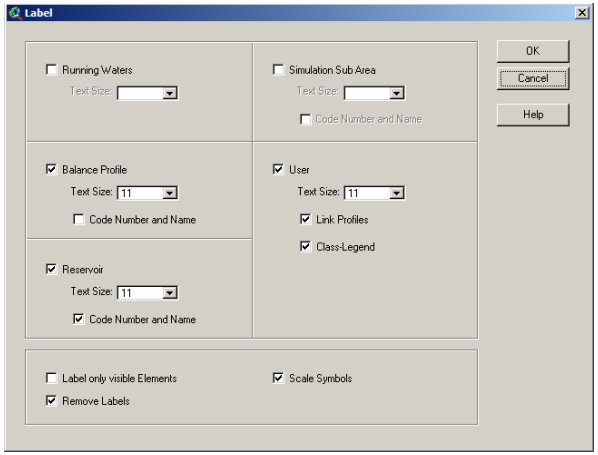
Labelling the System Sketch

Variant

Menu Graphic

Label

Button



- The model elements displayed in the system sketch, namely Running Waters, Balance Profiles, Reservoirs, Simulation Sub Areas, and User, respectively, are labelled by activating the relevant control box.
  - The **text size** can be set between 6 and 20 points. The initial value, font style and its section have to be established in the WBalMo options (chapter 2.6 Options).
  - **Name and Code Number**: names can be displayed next to their code numbers for Balance Profiles, Reservoirs, and Simulation Sub Areas.
  - **Users** are labelled with their code number and class. Lines can be generated between Users and their withdrawal profiles as well as their return flow profiles via **Connect Profiles**, alternatively. With this the colour red is used for withdrawal, reddish-brown for return flows and green for minimum discharges. The selection of individual, class specific colours for labelling of Users is possible after activating the **classes legend**. The utilised class legend can be edited in the WBalMo options.
- **All** or **only elements visible** are labelled in the system sketch, alternatively.
- By activating the control box **Scale Symbol**, text size and line thickness vary for different zoom factors. Otherwise they keep their size.
- **Existing labels are deleted** if required.

Labelling Individual Model Elements

Variant

Tool

- Model elements of **active themes** can be labelled individually by **clicking** on them.
- The name is displayed for Running Waters. For Balance Profiles, Reservoirs, and Simulation Sub Areas code numbers are displayed, respectively. For Users code number and class are displayed.
- Labelling takes place according to parameters in the general program settings (chapter 2.6 Options).

Delete Labels

Variant

Menu Graphic

Delete Labels

Memorise / Restore Graphic

The automatic labelling often is not sufficient to ensure an optimal labelling of elements in the system sketch. E. g., overlapping inscriptions have to be moved manually. The state of a satisfying graphic can be saved by **Memorise Graphic**. This state can be „brought back“ after further changes by **Restore Graphic**.

Variant

Menu Graphic

Memorise

Restore

5.6.3. Creating a Legend

Insert Legend into System Sketch

Variant

Tool

- No theme must be active. Deactivation takes places by holding down the SHIFT key while selecting the corresponding theme with the mouse from the Table of Contents (TOC).
- A rectangle is to be marked in the system sketch by the tool. Thus the location and the size of the legend are defined.
- All visible themes, according to their appearance in the TOC, are displayed in the legend.
- By holding down the SHIFT key and repeatedly drawing rectangles, several legends can be inserted in the system sketch. Existing legends are deleted, if the SHIFT key is not pressed.

Delete Legend

Variant

Menu Graphic

Delete Legend

- All legends are deleted.

5.6.4. Modifying a Legend

The representation of model elements Running Waters (Rgw), Balance Profile (Bp), Simulation Sub Area (SSA), User, and Reservoir in the system sketch, including the background map, are modified in the following way:

- Establishing the level of a theme within the system sketch is accomplished by moving the theme in the Table of Contents (TOC)

upward or downward with the mouse (first mouse button).

- Editing the legend is possible after double clicking on the relevant theme (similar to ArcView Help „Edit legend“). The modified legend of WBalMo themes can be saved in the variant attributes.

5.6.5. Raster Activating / Deactivating

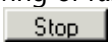
The model elements represented in the system sketch, namely Running Waters, Balance Profiles, Reservoirs, Simulation Sub Areas, and User, respectively, can be aligned to a raster by their new definition or by editing the system sketch. The utilisation and the size of the raster are established in variant properties.

With this function raster points, of new or moved model elements, are represented in the **visible map section**. An already existing raster can be deleted from the system sketch with this function.

Variant

Menu Graphic

Raster

The drawing of raster points can be cancelled by pressing 

in the ArcView status bar.

5.7. View

Zoom 100%

Variant

Menu View

Zoom 100%

Button

Pulldown Zoom 100%

Reactivate last Clip / View

Variant

Menu View

Enlarge / Reduce Previous Section

Button

Pulldown Enlarge / Reduce Previous Section

Updating Window

Variant

Menu View

Update Window

Enlarging Sections

Variant

Tool

Reducing Sections

Variant

Tool

Moving Sections

Variant

Tool

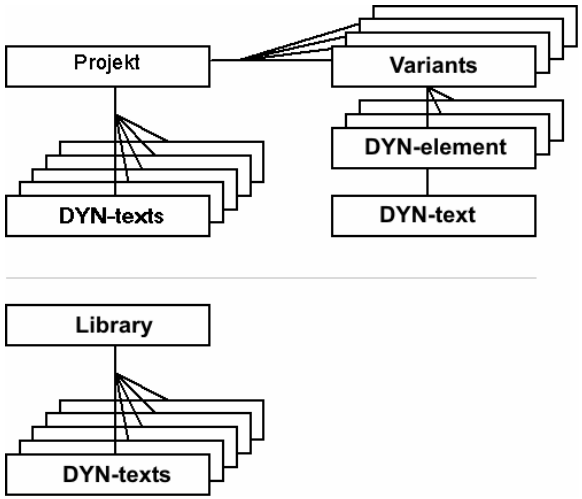
DYN-Texts

6

DYN-texts, passages of DYN-texts or other text based information can be stored **independent of variants** contained in the WBalMo-project as **DYN-text documents**.

This interface is considered to be the WBalMo **standard editor**. Alternatively an external editor can be integrated into WBalMo. Furthermore editing of DYN-texts, integrated into the variant, in the DYN-element dialogue is possible.

In the following figure the relations of project and variant linked DYN-texts are represented, as well as external ones, which are stored in libraries.



6.1. Libraries

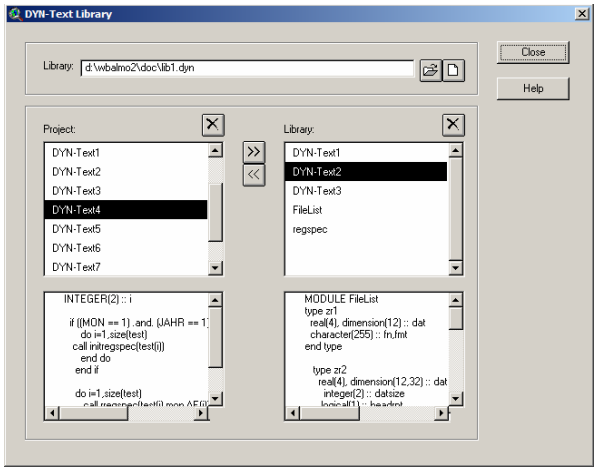
DYN-texts of the active project and external libraries can be administered with this function. External libraries for instance can be used for filing or exchanging of DYN-texts with other WBalMo users.

Project

Menu WBalMo

DYN-Text Library

Button



Project DYN-Texts

- The text of a DYN-text chosen from the list („Project“) is displayed in the lower section. Selection of more than one DYN-text is possible by clicking on the names whilst holding down the SHIFT key.
- Project
- After confirmation the selected DYN-texts are deleted from the project.

Library DYN-Texts (*.dyn)

- By a DYN-text library is opened. A new library can be established via the file dialogue . The default directory (file) is established in the WBalMo options.
- With the button DYN-texts selected in the project are stored in the library. Library texts with the same labelling are overwritten after confirmation.
- By all highlighted library texts are added to the project.

6.2. Searching for Character Strings in DYN-Texts

Project

Project Window

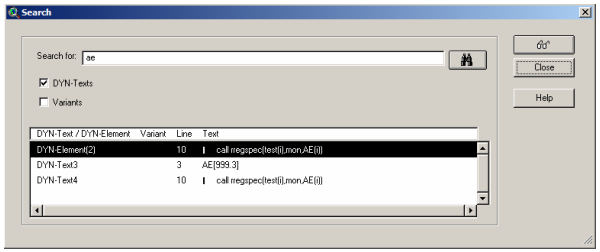
DYN-Texts

Search

DYN-Texts

Menu Extras

Search (global)



Search

- Enter character string to be found.
- Establishing documents for the search. The projects DYN-texts and variants DYN-elements can be searched through.
- After pressing the button the search starts.
- The name of the DYN-text / DYN-element, variant name, line number and the text lines are displayed as a result. No information about variant names for the projects DYN-texts is given.

Opening DYN Texts / DYN-Elements

- With the button the selected DYN-text / DYN-element is opened.

6.3. Editor

Menu Project

- **Save**

  Saves the Project

- **Print**

  Prints the active DYN-text

  ☹ If the text is wider than the set page, the remainder is printed on the following page.

  ☹ Some printers may produce faulty texts. To solve this problem

  o use the external editor for the printout of DYN-texts

- o install a relevant driver for your printer or
- o use a post script printer.

- **Printer Set Up**

  Determines the relevant printer and its properties

Menu Edit

- **Undo**

  Undoes the last input

- **Cut**

  Removes the highlighted area and stores it in the clipboard

- **Copy**

  Copies the highlighted area into the clipboard

- **Paste**

  Pastes the contents of the clipboard to where the cursor is positioned, any highlighted area is overwritten

- **Highlight All**

  Highlights the whole DYN-text

- **Shift to the left**

  Shifts the highlighted lines 2 characters to the left

- **Shift to the right**

  Shifts the highlighted lines 2 characters to the **right**

- **Cursor Position**

  Displays the current cursor position in the status line

- **Command Line**

  Pastes six blanks at the beginning of the line in which the cursor is situated, provided that this line is not yet marked as a command line (without consideration of skip marks)

- **Continuation Line**

  Pastes five blanks and a „&“ at the beginning of the line in which the cursor is situated, provided that this line is not yet marked by „&“ or „F“ as a continuation line

- **Search**

  Searches the whole DYN-text document for the highlighted or entered character string

- **Continue Search**

- **Replace**

  Replaces the highlighted or entered character string with another character string

Menu DYN-Text

- **Name**

  Establishes a name

- **Text Size**

  Sets the size of the text (small, medium, large)

- **Paste Text-file**

  Pastes the contents of a text-file to where the cursor is positioned, any highlighted area is overwritten

- **Save as Text-file**

  Writes the DYN-text into a file

- **External Editor**

  Starts the external editor (chapter 2.6 Options) with the active DYN-text

- **Convert Character Set**

  Converts all special characters into a Windows character set

Menu Extras

- **Search (global)**

  Starts the search for character strings in DYN-texts

Example

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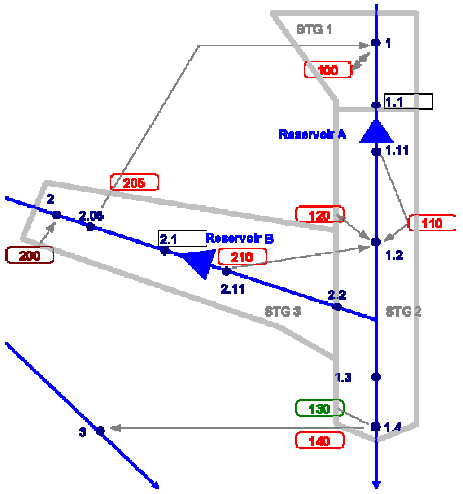
This example should help to make WBalMo easier to use. A water management system cosisting two (main) rivers and a tributary is examined, in which both rivers are only connected to one another by an artificial diversion. In total the system is comprised of 8 Users and Reservoir A. Furthermore it is assumed that this system can only guarantee a few water utilisations with sufficient reliability. Therefore it should be examined, if this situation can be improved with the help of a new Reservoir - Reservoir B. For this investment problem it will be useful to investigate the system behaviour for three successive periods:

Period 1:	present system with Reservoir A
Period 2:	system with the new Reservoir B in the nonstationary starting phase
Period 3:	system with Reservoir B in the stationary state

The length of the periods is presumed to be 4 years, and the realisations starting year is set at 1999. Via a suitable registration the effectiveness of the new Reservoir is to be proved.

Corresponding to the graphical representation of the system in the figure, the system is to be described with the help of data classes together with natural runoff and water utilisation processes.



Model Structure

12 Balance Profiles (Bp) are defined for a suitable geographical representation of water utilisations, in which Bp 1.11 and 2.11 represent Reservoir release profiles.

1 1.1 R 1.1 1.11 1.2 1.3 1.4 ➔ ∅

2 2.05 2.1 R 2.1 2.11 2.2 ➔ 1.3

3 ➔ ∅

Simulation Sub Areas (SSA)

For the acquisition of the natural water yield, 3 SSA are defined according to the position of three observed, long term water gauges:

Gauge Adorf	in Bp 1.1 (as inflow gauge of Reservoir 1.1)
Gauge Bestadt	in Bp 1.4 (contains the discharges of both other gauges)
Gauge Cedorf	in Bp 2.2 (gauge at the river mouth of the tributary).

The natural yield of the second main river in Bp 3 is of no interest. The figure shows the position of the SSA.

For the gauges long, chronological corresponding and revised mean monthly discharge series have to be provided. In the example, revision concerns losses caused by Users situated upstream in the respective SSA, and also the effects of Reservoir A. These series can either be entered into the WBalMo calculation or they can serve as a basis for the construction of a stochastic discharge simulation model. The latter case results in series of any length as prerequisite for WBalMo results of high accuracy, and should be preferred.

The following is valid for the SSA:

Name	Code Number	File
SSA 1	1	adorf.dat
SSA 2	2	bstadt.dat
SSA 3	3	cdorf.dat

The SSA-series provided for the example contain 1200 years, each containing 12 months. They enable a WBalMo calculation with a maximum of 100 realisations for each of the 3 periods, every period being 4 years in length.

Since several Balance Profiles usually are located in a SSA, the water availability of a SSA is divided into relative shares between successive Bp in the respective SSA. These shares are mostly determined via the proportion of ‚share on the SSA' / ‚whole SSA area', in addition more exact calculations consider the average precipitation levels within a SSA.

The following values are assumed:

Bp	1	1.1	1.11	1.2	1.3	1.4	2	2.05	2.1	2.11	2.2	3
SSA 1	0.9	0.1		-0.3	-0.45	-0.25						
SSA 2				0.3	0.45	0.25						
SSA 3				-0.3	-0.45	-0.25	0.2	0.3	0.4		0.1	

In the example it is assumed, that 90 % of the water available in SSA 1 originate at the area upstream of Bp1 and the remaining 10 % originate from the area between Bp1 and 1.1. SSA 2 represents a special feature, as the used discharge in Bp 1.4 contains discharges of SSA 1 and 3. The surface shares between Bp 1.1, 1.2, 1.3, and 1.4 amount to 30, 45 and 25 % of the area of SSA, respectively. This means that discharge between Bp 1.1 and 1.2 is 0,3*(SSA2-SSA1-SSA3), increases between Bp 1.2 and 1.3 to 0,45 (SSA2-SSA1-SSA3) etc (the negative shares can be avoided by using the difference series of discharge at the 3 gauges). No natural yield is allocated to both Reservoir release profiles 1.11 and 2.11.

User

The necessary details about the 8 Users contains the following table:

Name	**Code Number**	**Type**	**EP**	**RP**	**ME**	**E**	**R**	**Rank**
Chemical plant	100	R+	1	1	hm³/Mon	1.5	1.2	0.6
Steel plant	110	R+	1.1	1.1	km³/d	150	135	2
Irrigation	120	R+	1.2	1.2	hm³/Mon	*)	0	5
Minimum discharge for navigation	130	Qmin	1.4		m³/s	35		1
Transmission to other basin	140	R+	1.4	3	m³/s	10	10	4
Sewage treatment plant	200	CR+		2	hm³/Mon		1.1	0.5

Name	Code Number	Type	EP	RP	ME	E	R	Rank
Transmission for Reservoir replenishment	205	R+	2.05	1	m³/s	0 **)	0 **)	7
Power plant	210	R+	2.11	1.2	m³/s	10	9	3

*) Annual Cycle:

May	2.2
June	5.0
July	6.0
August	6.0
September	2.2
else	0

**) The real withdrawal and return flow quantities are calculated in a DYN-element.

All User details are valid for the 3 periods.

Reservoir

Both Reservoirs are defined by the following details.

Name	Code Number	Cap	FSK	NG		Rank (AEND)
		hm³		Period 1	Periods 2, 3	
Reservoir A	1.1	250	0.5	*)	*)	8
Reservoir B	2.1	350	0	0	350	6

*) Annual Cycle:

January	200
February	180
March	180
April	210
May	240
June	240
July	240
August	240
September	240

October	240
November	230
December	220

Reservoir A exists in all periods and has a different active Reservoir Capacity size in individual months. Thus a seasonally changing flood protection Capacity can be registered with ease. It is assumed that the Reservoir is half filled at the start of the calculation (FSK= 0.5)

Reservoir B is put into operation at the beginning of the 2nd period, so that its Active Reservoir Capacity size is set to zero in period 1. Afterwards a constant Active Reservoir Capacity size is taken.

Release-Elements

The management of both Reservoirs is controlled by 3 Release-elements, according to the following information.

Name	Code Number	Reservoir	G	BETA	Rank
Release for Qmin for navigation	1.11	1.1	10	0	0.99
Release for irrigation	1.12	1.1	160	0	4.99
Release for transmission and power plant	2.1	2.1	0	0	2.99

Both of the first named elements set Reservoir A's Target Storage Level to 10 and 200 hm³, respectively. That means, in connection with the accompanying ranks, water quantities above the Target Storage Level are available to the following Users according to their rank. Each time the current Reservoir Storage Level is below the Target Storage Level, the Users receive no Reservoir support. On the contrary, it is attempted to use a proportion of the Reservoir inflow for the replenishment of the Reservoir.

The 3rd Release-element regulates, that all water available in Reservoir B is provided for the Users of subsequent ranks.

C-Field

The capacity of the connection, to replenish Reservoir A with water available in the tributary, which is required in the DYN-element, is deposited in the 2nd field element of the C-field:

Index	Value	Name
2	5	max. capacity of the connection at Bp 2.05 in m³/s

DYN-Elements

The transmission to Reservoir A is regulated by the only DYN-element of the system:

Name Calculation of the transmission for reservoir replenishment

Rank 6.99

DYN-text

```
IF (X[2.05] > 5.*2.628 .AND. SI[1.1] < 150.)
THEN
 C(1) = MIN (X[2.05] - 5.*2.628, C(2) * 2.628)
ELSE
 C(1) = 0.
END IF
E[205] = C(1)
R[205] = C(1)
END
```

The algorithm determines, that only at discharges at Bp 2.05 over 5 m^3/s and Reservoir fillings below 150 hm^3 transmissions are allowed. The amount is limited by the portion of discharge exceeding 5 m^3/s and by the connection capacity of 5 m^3/s established in C(2). It is important that the rank of the DYN-element is lower than that of User 205.

Ranking List

According to the simulation of water utilisation processes in WBalMo, all elements with ranks (User, Release- and DYN-elements) are sorted ascending in a ranking list. This list, starting with the lowest rank, then is gradually worked off.

In this example the following list is produced:

Type	Code Number	Name	Rank
N	200	Sewage treatment plant	0.5
N	100	Chemical plant	0.6
AB	1.11	Release for Qmin for navigation	0.99
N	130	Qmin navigation	1
N	110	Steel plant	2
AB	2.11	Release for transmission to other basin	2.99
N	210	Power plant	3
N	140	Transmission to other basin	4
AB	1.12	Release for irrigation	4.99
N	120	Irrigation	5
AEND	(2.1)	Reservoir B	6
DYN		Calculation of the transmission for Reservoir replenishment	6.99
N	205	Transmission for Reservoir replenishment	7
AEND	(1.1)	Reservoir A	8

I. e.,

- independent of all conditions the sewage plant releases its return flow to Bp2 and the chemical plant is allowed to withdraw water, as long as the water yield at Bp1 is sufficient,
- the current Storage Level of Reservoir A is allowed to be lowered to the Target Storage Level of 10 hm^3, in order to support navigation (N 130) and steelworks (N 110) with priority,
- the new Reservoir B supplies, with its entire current Capacity, above all, the power plant (N210) and the transmission to the other basin (N140),
- Reservoir A supports irrigation (N120) only, if its current Capacity is above 160 hm^3 and
- the replenishment of Reservoir A from the tributary only occurs under conditions set in the DYN-element,
- Reservoir B has priority over Reservoir A concerning Reservoir replenishment during phases of high discharges (rank(AEND 2.1) < rank(AEND 1.1), by this a better utilisation of Reservoir B's larger Storage Capacity is aspired).

Registrations

To enable the evaluation of the effectiveness of the given management concept, the following registrations have been set:

Type	Term	Name	Result
1	X[1.4]	Discharge at Bp 1.4	Reliability of minimum discharge for navigation
1	AE[210]	Actual withdrawal of power plant	Reliability of supply for power plant
1	100*AE[140]/E[140]	Relative satisfaction of requirements for transmission	Reliability of demand for transition into other basin
2	X[1.4] < E[130]	Under-run of minimum discharge for navigation	Frequency of under-run lasting several month
3	SI[1.1]	Storage Level Reservoir A	Mean Storage Level Reservoir for selected years
3	SI[2.1]	Storage Level Reservoir B	Mean Storage Level Reservoir for selected years
3	AE[140]	Quantity of transmission to other basin	Mean quantity of transmission in individual years

Results

The calculated system, the discharge and water utilisation processes within this system are fully described by the above data. The results are stored in a file after a simulation with 100 realisations. A short discussion of the results should help explain how they are to be interpreted.

From the three registrations of type 1 the following essential properties can be concluded:

Registration Figure	Term	Value	Reliability [%]	Period 1	Period 2	Period 3
Discharge at Bp 1.4	X[1.4]	35 m³/s	S (October)	76.0	92.8	93.5
			SD	91.1	96.4	97.0
Actual withdrawal of power plant	AE[210]	10 m³/s	S (October)	70.5	89.3	92.3
			SD	89.4	96.5	97.3
Relative satisfaction of requirements for transmission	100*AE[140]/E[140]	100 %	S (October)	67.5	90.0	93.3
			SD	87.3	96.0	96.5

The results show for period 1, in which Reservoir B does not yet exist, that both the reliability in October (in the example the worst month in general) and the reliability according to the duration for relevant values are very low. The reliability of 76 % for the minimum discharge of 35 m^3/s for navigation in October means, that it can only be maintained approximately in 3 of 4 years in the month of October, on average. The SD reliability of 91.1 % reveals, that a fall below the minimum discharge is to be expected every 10 months, approximately. Reliabilities concerning both other essential uses are even lower, for a power plant they are totally unacceptable. The system existing in period 1 is overloaded.

From the very beginning of the second period Reservoir B begins to prove its duty as reliabilities strongly increase and achieve acceptable dimensions. If reliabilities of periods 2 and 3 are compared with one another, again a slight increase can be detected. This is caused by the fact, that the filling phase of the new Reservoir B is completed in period 3.

Registration type 2 investigates the frequency of starts of discharge phases below the minimum discharge lasting several months in Bp 1.4, in individual months. By addition of frequencies, e.g. in September, can be recognised, that a phase lasting several months begins with a probability of approximately 6 % in period 1, this probability falls to approximately 2 % in both other periods. For the remaining months a similar trend can be seen. These results underline the statements of registration type 1.

The next two tables of registration type 3 reflect the mean Storage Level behaviour of both Reservoir A and B over the 12 years of the simulated time series. If only the mean yearly Storage Level is considered, at Reservoir A a gradual increase from period 2 can be seen in connection with the filling of Reservoir B. Period 3 is characterised by consistently high mean Storage Levels. A corresponding behaviour is indicated for the new Reservoir B from period 2. However, the start of Reservoir B's stationary storage phase can also be seen by the stabilisation of the mean lowest Storage Level (MNQmon) in period 3.

The last table of registration type 3 indicates the mean quantity transmitted to the other basin. The putting into operation of Reservoir B is accompanied by an increase in transfers, on average 8,9 m^3/s in period 1 and approximately 9,7 m^3/s in both other periods.

A change in a Reservoirs Target Storage Level, as well as changes for User ranks, Release- and DYN-elements, respectively, can result in changes in the reliability of different Users. With water utilisation demands maintained and an established system of significance of individual Users, the development of approximately optimal management strategies with the help of variant calculations is possible. If some reliabilities stay below an expected level, some

water utilisation demands have to be either withdrawn or further management measures (construction of further Reservoirs and connections) have to be taken into consideration.

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Contact

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WASY Gesellschaft für wasserwirtschaftliche
Planung und Systemforschung mbH

Waltersdorfer Straße 105, 12526 Berlin

Telephone: (030) 67 99 98 - 0

Fax: (030) 67 99 98 - 99

e-mail: support@wasy.de

WWW: http://www.wasy.de

WASY Gesellschaft für wasserwirtschaftliche
Planung und Systemforschung mbH - Niederlassung Dresden

Goetheallee 21, 01309 Dresden

Telephone: (0351) 31 61 611

Fax: (0351) 31 61 612

e-mail: ddwasy@wasy.de